BACHELOR THESIS & COLLOQUIUM – ME-141502

STORAGE CALORIFIER DESIGN FOR DOMESTIC WATER HEATING SYSTEM ONBOARD PKR SHIP

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MARINE ENGINEERING DEPARTMENT
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Institut Teknologi Sepuluh Nopember-Hochschule Wismar
Surabaya
2017

APPROVAL SHEET

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BACHELOR THESIS

Submitted to Comply One of the Requirements to Obtain a
Bachelor of Engineering Degree
In
Double Degree of Marine Engineering (DDME) Program
Departmen of Marine Engineering-Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember (ITS)
Department of Marine Studies

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SURABAYA
January , 2017

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INSTITUT TEKNOLOGI SEPULUH NOPEMBER
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Department	: Marine Engineering

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Surabaya, Januay 2017

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STORAGE CALORIFIER DESIGN FOR DOMESTIC WATER HEATING SYSTEM ONBOARD PKR SHIP

Student Name : Lusi Fadilah
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ABSTRACT

Air pollution is the main cause of global warming effect that is a main issue nowaday in the modern era. Today almost all goods are transported via sea by using ships worldwide. Diesel engine is used mostly as their prime mover. Among all types of vehicles in the world, ship is the the biggest producer of air pollution based on the quantity of fuel consumption. According to MARPOL 73/78 Annex VI, air pollution must be prevented either by utilizing exhaust gas from the engine

Thermodynamically and mechanically, the maximum efficiency of diesel engine is around 60%. While the rest 40% remains as wasted heat, and approximately 25-30% of it is in the form of exhaust gas. There are possibilities to reuse this heat for certain system on the ship.

In this study, storage calorifier is studied as the part of wasted heat recovery system. The aim of this study is to design storage calorifier on board PKR *(perusak kawal rudal)* ship, and to conduct technical studies on the designed domestic system. The methodology that is used is thermodynamic calculation based design and software based design using HTRI Software. The results will be compared to determine the performance of the system and then used to acquire the economic analysis from saving fuel oil of auxiliary engine. One of the final results is comparison between software based and calculation based design, with the obtained over design is 6.13 %. Heat Exchanger Research Inc. (HTRI) 6.0 the results obtained are not too much difference. From calculation based design, the obtained area is 640.076 ft^2 while the obtained area of software based design is 494,406 ft^2 . For Overall Coeeficient from manual calculation be obtained 6.5 btu/ft^2.h.F and from HTRI software is 6.96 btu/ft^2.h.F. For over design from calculation manual and htri software is 6.13 %. The economic analysis results that is after using the storage calorifier, fuel consumption of auxilary engine at 50%MCR can save 139659 liter/years.

***Keywords* –Air pollution , Waste Heat Recovery, Storage Calorifier , Calculation based design, software based design, Economic Analysis.**

DESAIN TANGKI CALORIFIER UNTUK SISTEM PEMANAS AIR DI KAPAL PKR

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ABSTRAK

Polusi udara merupakan penyebab terjadinya pemanasan global yang saat ini menjadi isu uatama.Di era saat ini hampir semua kebutuhan ditransportasikan melalui jalur laut menggunakan media kapal secara global. Mesin diesel banyak digunakan sebagai penggerak utama kapal. Dari semua tipe kendaraan didunia, kapal merupakan produsen polusi terbesar berdasarkan konsumsi bahan bakar. Menurut MARPOL 73/78 Annex VI, polusi udara harus dicegah baik dengan cara memanfaatkan gas buang dari mesin.

Secara termodinamik dan mekanik , effisiensi maksimum dari mesin disel adalah sekitar 60%. Sementara 40% sisanya sebagai panas buang dan diperkirakan 25-30% nya berupa gas buang. Banyak kemungkinan untuk menggunakan kembali panas buang ini untuk sistem tertentu diatas kapal.

Di tugas akhir ini, tangki calorifier dipelajari sebagai salah satu bagian dari sistem pemanfaatan panas buang. Tujuan dari tugas akhir ini adalah mendesain tangki calorifier diatas kapal PKR (perusak kawal rudal) dan analisa teknik desain sistem pemanas air. Metode yang digunakan oleh penulis dalam tugas akhir ini adalah perhitungan desain secara manual dan desain menggunakan software HTRI kemudian dibandingkan untuk menentukan kinerja sistem dan untuk menganalisa segi ekonomi dari konsumsi bahan bakar dari auxilary. Dari hasil perbandingan perhitungan manual area perpindahan panas 640,076 ft2 sementara area perpindahan panas dari software HTRI adalah 494,406 ft2. Untuk koefisien perpindahan panas keseluruhan dari perhitungan manual diperoleh 6,5 btu / ft2.h.F dan dari software HTRI adalah 6,96 btu / ft2.h.F serta kelebigan desain 6,13%. Berdasarkan analisa ekonomi setelah menggunakan tangki calorifier fuel oil cunsumption dari auxilary pada 50%MCR dapat disimpan sebanyak 139659 liter/tahun.

***Kata Kunci* – Polusi Udara, Pemanfaatan Gas Buang, Tangki Calorifier , Pperhitungan Desain , software HTRI, Analisa Ekonomi.**

PREFACE

First and foremost, the author would like to give a huge thanks to Allah SWT the God Almighty for giving intelligent, strength, health and favors so writers can have finished this bachelor thesis.

This bachelor thesis aims to design storage clarifier for domestic water heating system onboard pkr ship.

The author also would to express his immeasurable appreciation and deepest gratitude for those who helped in completing this Bachelor Thesis:

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The author realizes that this thesis remains far away from perfect. Therefore, every constructive suggestion and idea from all parties is highly expected by author for this bachelor thesis correction and improvement in the future.

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Surabaya, Jan 2017

TABLE OF CONTENTS

TABLE OF FIGURE

LIST OF TABLE

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CHAPTER 1
INTRODUCTION

1.1 Background

Air pollution is the main cause of global warming effect that is a main issue nowaday in the modern era. Today almost all goods are transported via sea by using ships worldwide. Diesel engine is used mostly as their prime mover. Among all types of vehicles in the world, ship is the the biggest producer of air pollution based on the quantity of fuel consumption. According to MARPOL 73/78 Annex VI, air pollution must be prevented either by utilizing exhaust gas from the engine.

Thermodynamically and mechanically, the maximum efficiency of diesel engine is around 60%. While the rest 40% remains as wasted heat, and approximately 25-30% of it is in the form of exhaust gas. There are possibilities to reuse this heat for certain system on the ship.

From the planning that had been made, the writer could know Storage Calorifier technology which is normally applied to the building is suitable for domestic water heating system on the ship PKR or not, and could determine the performance of the system.

1.2 Statement Of Problems.

Based on the description above the statement problem of this thesis are:

a. How many the amount of required of exhaust gas for hot water in the domestic systems PKR ship ?
b. How the comparison design calculation with software HTRI ?
b. How is the back pressure of exhaust gas system due to the modification of exhaust gas system ?

d. How the operational of domestic water heating system with strorage calorifier?
f. How the system analysis in terms of economic ?

1.3 Research Limitation

a. Design Storage Calorifier will be made only used for domestic systems only.
b. System design using existing domestic systems on PKR ship.
c. The analysis were performed on fresh water system (hot water) for bathing in PKR ship at a temperature of 38^{o} C.

1.4 Research Objectives

1. Technical Analysis
   a. To know the amount of required exhaust gas for hot water in the domestic systems of PKR ship.
   b. To know the comparison design of manual calculation with software HTRI .
   c. To know the back pressure result from the modification of Auxilary Engine’s exhaust gas system.
   d. To know the operational of of domestic water heating system with strorage calorifier.
2. Economic Analysis
   a. To know the fuel oil saving after adding the storage calorifier system.

1.5 Research Benefits

a. Knowing whether the use of waste heat can be applied to the domestic systems on PKR ships or not.
b. Getting the appropriate design for design planning Storage Calorifier Storage Calorifier applied to the domestic systems on ships PKR.

c. Knowing the modified keyplan (PID including detail specification of all equipment) , and modified E/R arrangement / layout.
d. Knowing performance and best design of Storage Calorifier Storage Calorifier that applied at domestic systems on PKR ships.
e. Knowing the economic analysis of Storage Calorifier using waste heat recovery system

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CHAPTER 2
LITERATURE REVIEW

2.1 Overview

There are many type of the Air pollutants, such as carbon monoxide (CO), sulfur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs), ozone (O3), and reaction from this pollutan will be decomposition in long time. [**1**]

Maritime transport is the fifth largest contributor to air pollution and carbon emissions, and the growth rate of trade makes the problem even more pressing. Figure 2.1 show that the emissions from marine engines with per - cylinder displacement at or above 30 litres (also called Category 3 marine diesel engines) are considered to be significant contributors to air pollution [**2**].

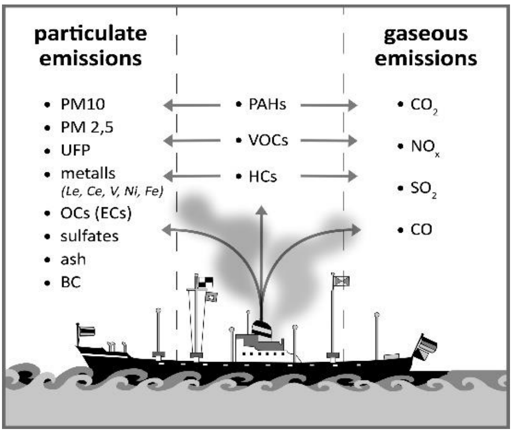

Figure 2. 1 Characterized compounds of emissions from marine vessel engines

NOx emission can be reduced by primary methods such as retard injection, fuel nozzle modification, change of compression ratio, water direct injection, water emulsification, exhaust gas recirculation (EGR), secondary method such as selective catalytic reduction (SCR) and waste heat recovery system.

Fuel reductions of between 4-11% are possible, depending on the selected (Waste Heat Recovery System) WHRS solution, main engine power level, electric need at sea, operational profile, etc. The larger the engine power, the greater the possible fuel saving. In addition to large fuel savings, a WHRS gives large CO2, NOx, SOx and particulate reductions to the benefit of the environment. [**3**]

2.2 Waste Heat Recovery System (WHRS)

Waste heat recovery systems recover the thermal energy from the exhaust gas. There are many source of exhaust gas at the ship such as main engine, auxilary engine, boiler, and etc. Waste heat recovery system is one of the best energy saving methods to increase the efficiency of fuel use. The example when sailing, the diesel engine has an efficiency of about 48-51% and the remainder of the input energy is released to the atmosphere through exhaust gas and jacket water. [**4**]

In diesel engines, there are many heat source with significant potential to be tapped, can be seen in the figure 2.2 such as shaft power , lubricating oil , jacket water , Exhaust gas , Air Cooler , Heat radiation. [**5**] All Waste heat source potential to be reused to produce energy, for example, is used as a driver generator, producing electricity and for heating purposes.

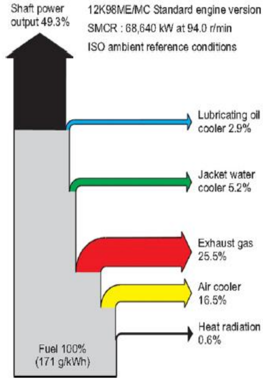

Figure 2. 2 Heat balance diagram of the nominally rated 12K98ME/MC engine of the standard engine version operating at ISO ambient reference conditions and at 100SMCR

The amount of waste heat available in the exhaust gas is determined by temperature and mass flow rate of the exhaust gases, according to the equation:

$$Q = \dot{m} \times C_p \times \Delta T \quad (2.1)$$

Where :

Q = Heat Loss [kJ/min]

$\dot{m}$ = Mass flow rate exhaust gas [kg/min]

C_p = Specific heat of exhaust gas [kJ/kg K]

ΔT = Temperature difference [K]

2.3 Storage Calorifier

Calorifier is a unit of equipment to move heat from steam to water or hot water. This heat transfer process using a pipe fin or pipe / tubing are placed in a tank or tube.

There are many types of calorifier dependent from heat sorce from calorifier, such as electric, gas burn, steam. The working principle of electric water heater tank system is almost the same as the cooking water using electricity (electric thermos). The water is collected in an insulated tank equipped with air pipe coiled electrical heating element. [**6**] Heat transfer / heat that occurs will be absorbed by the water in the tank. In the tank there are three main elements, namely:

1. Heating element, is used to heat water
2. Thermostat, serves to maintain the condition of the water in the tank stays hot at a certain temperature
3. Magnesium anode, serves to neutralize the positive ions in water to help prevent rust on the elements in the tank.

Further specification of the existing system on PKR ship can be seen in ecnlosure C .

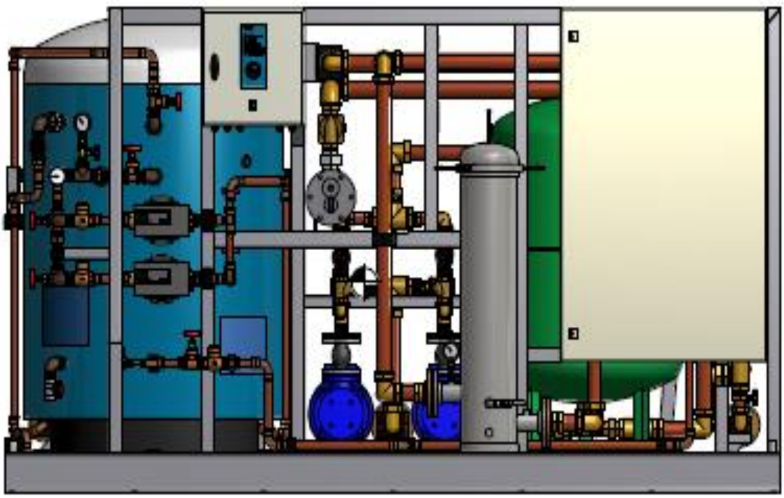

Figure 2. 3 Calorifier

2.4 *Perusak Kawal Rudal* (PKR) SHIP

Figure 2. 4 PKR ship

Perusak Kawal Rudal (PKR) or guided-missile frigates designated for the Indonesian Navy (TNI AL). Primarily, the vessel will be operated for Anti-Air Warfare, Anti-Surface Warfare, and Anti-submarine Warfare. However, it is also compatible with Maritime Security, Search and Rescue, Patrol, and Humanitarian Support tasks. TNI-Al will be strongly empowered by this state-of-the-art maritime capacity.

PKR has a length of 105.11 metres, a beam of 14.2 metres and a displacement of 2,365 tons. The vessel features a fully air-conditioned accommodation for up to 122 persons. The frigate has a speed of 28 knots, and can sail up to 5,000nm at 14 knots. The endurance is at least 20 days at sea.

PKR ship is a SIGMA class frigate. This ship propulsion system is a hybrid CODOE (Combined Diesel or Diesel-Electric) system. The CODOE system is that uses 2 main diesel engines or 4 auxiliary diesel engines to propel the ship.like the figure 2.5 below. The propulsion system of the PKR vessel utilises a combined diesel or electric (CODOE) which consists of two 10,000kW maximum continuous rating (MCR) diesel engines, two 1,300kW electric motors, two double input gearboxes and two 3.65 metre controllable pitch propellers. The vessel is equipped with a sophisticated platform management system that enables operating, control and monitoring of the ship's auxiliary systems. The vessel will naturally be equipped with a complete, state-of-the-art sensor and weapon package to counter air, surface and sub-surface threats. For self-defence, the vessel is also equipped with comprehensive electronic warfare systems.

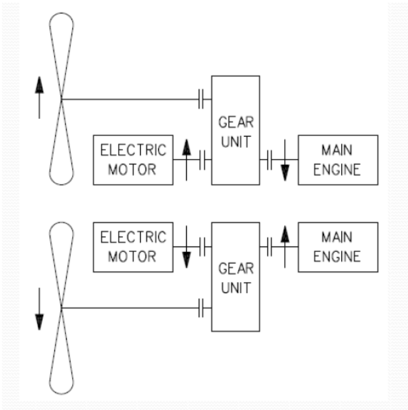

Figure 2. 5 CODOE system

2.5 Htri Software

Research conducted by the design. This design in the form of calculating the dimensions of a heat exchanger shell and tube type using computerized analysis of Heat Transfer Research Inc. (HTRI) and the method analysis of manual calculation. Calculating the dimensions of a heat exchanger is intended to determine the quality of a heat exchanger is based on the overall heat transfer coefficient, fouling factors, and the pressure drops will occur. Heat exchanger designed is a heat exchanger type shell and tube 1 (one) pass shell and one (1) pass tube counter-flow with exhaust gas and cold fluid is water. The results of calculation of dimensional analysis showed that a heat exchanger designed already meet the minimum requirements of fouling factor has been determined. The quality of heat exchanger increases in proportion to the declining value of fouling factor, decreasing the value of the pressure drop and the magnitude of the dimensions of a heat exchanger. [**7**]

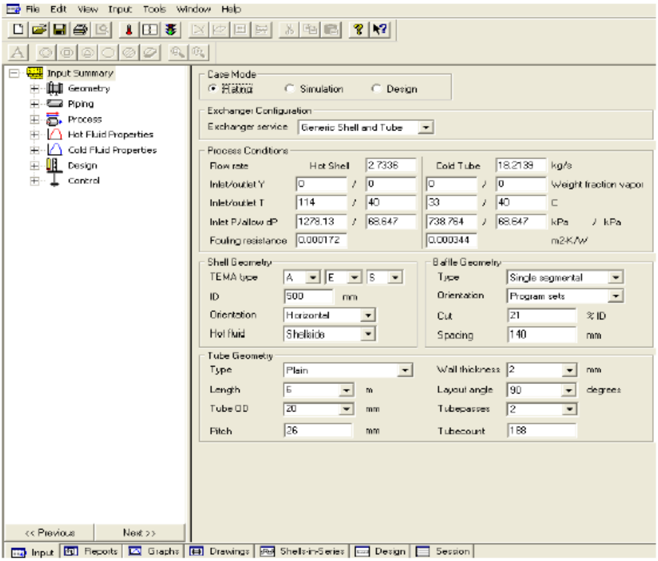

Figure 2.6 HTRI Simulation[1]

2.6 Paper Review

The wasted heat on a marine vessel is primarily the fuel energy which is lost to the environment from various ongoing processes during normal operations, e.g. thermodynamic heat transfer. For a diesel powered vessel, the diesel engine is the largest source of wasted heat [**8**].

---

1 *Bizzy I and Setiadi R, "Studi Perhtiungan Alat Penukan Kalor Tipe Shell And Tube Dengan Program Heat Transfer Research Inc. (HTRI)," Jurusan Teknik Mesin, Fakultas Teknik, Universitas Sriwijaya, 2013.*

The energy balance of a 2-stroke large marine diesel engine and shows that about 50% of the total fuel heat energy is rejected to the surroundings via different streams without doing any useful work [**9**].

The temperature range of exhaust gas varies for two-stroke and four-stroke engines, with the latter having higher exhaust temperatures. While the exhaust temperatures vary depending on load and ambient conditions, for nominal loads the range lies between 325–345 ^{o}C for two-stroke and 400–500 ^{o}C for fourstroke engines . Together with a high mass flow rate and a reasonably high temperature the exhaust gas offers itself as the best waste heat source, both in terms of quantity and quality. The utilization of exhaust gas energy depends on the lowest temperature to which it could be cooled in a heat exchanger [**10**].

A WHRS can be designed to operate either on a single or a combination of different heat sources.

2.7 Estimating The Engine %MCR Based On RPM

To estimate the RPM based on engine %MCR of main engine is using a formula :

$$\frac{P_1}{P_2} = \frac{(n_1)^3}{(n_2)^3} \quad \text{(2. 2)}$$

$$P_1 = \frac{(n_1)^3 P_2}{(n_2)^3} \quad \text{(2. 3)}$$

As per equation 2.3, the RPM of main engine can be calculated based on how much the desired %MCR.

$$n_1 = \left(\frac{P_1 (n_2)^3}{P_2}\right)^{1/3} \quad \text{(2. 4)}$$

Where :

n_1 = Given RPM

n_2 = Max RPM (100% load)

P_1 = (% MCR) at n_1
P_2 = (%MCR) at n_2 (100% RPM)

2.8 Find Out The Kw At Certain Rpm Or Certain Load

To find out the kw at certain rpm or certain %MCR of main engine is using a formula:

$$KW = \%MCR\ x\ Max.KW\ of\ M/E \text{ .... (2. 5)}$$

Where :
KW = Power of Main Engine (Kw)
$\%MCR$ = %MCR of Main Engine
$Max\ KW\ of\ M/E$ = Maximum Power of Main Engine (Kw)

2.9 Mass Flow Rate Of Exhaust Gas

To find out the mass flow rate of exhaust gas is using a formula :

$$\dot{m}_E = \dot{m}_f + \dot{m}_a \text{ .... (2. 6)}$$

Where :
$\dot{m}_E$ = Mass Flow Rate of Exh Gas (kg/s)
$\dot{m}_a$ = Mass Flow Rate of Air (kg/s)
m_f = Mass Flow Rate of Fuel (kg/s)

2.8.1 Mass Flow Rate Of Fuel

To find out the mass flow rate of fuel is using a formula:

$$\dot{m}_f = s.f.c \times Power \text{ .... (2.7)}$$

Where :
m_f = Mass Flow Rate of Fuel (kg/s)

$s.f.c$ = Spesific Fuel Consumsion (g/kwh)
$power$ = Power (Kw)

2.8.2 Intake Air Mass Flow Rate

To find out the Intake Air Mass Flow Rate is using a formula:

$$\dot{m}_a = \eta_v \times \rho_a \times n \times V_s \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.8)$$

Where :
$\dot{m}_a$ = Mass Flow Rate of Air (kg/s)
η_v = Effiency
ρ_a = Air density at atmospheric Condition (kg/m^3)
n = Engine Speed (RPM)
V_s = Displaced Volume (m^3)

2.10 The Rules Of Hot Water Needs At Ship

Based on MLC (Marine Labour Convention) at Regulation 3.1 about Accomodation and Recretional Facilities [**11**]:

1. Point A3.1 number 11 D
   " With the exception of passenger ships, each sleeping room shall be proved with a washbasin having hot and cold running fresh water, except where such a washbasin is situated in the private bathroom provided."
2. Point A3.1 number 11 F
   "Hot and cold running fresh water shall be available in all wash places."
3. Point B3.1.9 Other Facilities
   "Where separate facilities for engine department personnel to change their clothes are provided, they should be:
   a. Located outside the machinery space but with easy access to it; and

b. Fitted with individual clothes lockers as well as with tubs or showers or both and washbasins having hot and cold running fresh water.”

2.11 The Calculation Rules From Hot Water Needs At Ship

Based on *Merchant Shipping Act Chapter* 179 *Section* 100 about Crew Accommodation Requirements Part III Sanitary Arrangement [**12**]:

6) Cold fresh water and hot fresh water or means of heating water shall be available in all communal wash places.
   (a) the crew shall be provided with
      (i) fresh water of capacity sufficient to provide at least 72 litres per man per day and drinking water of capacity sufficient to provide at least 18 litres per man per day; or
      (ii) drinkable water of capacity sufficient to provide at least 90 litres per man per day if the fresh water provided under sub-paragraph (i) is also of drinkable quality;
   (b) the number of days shall be sufficient to cover the longest voyage the ship is expected to undertake with a maximum of 30 days;
   (c) if a distilling or evaporating plant capable of producing
      (i) at least 144 litres of fresh water per man per day and at least 36 litres of drinking water per man perday; or
      (ii) at least 180 litres of drinkable water per man per day, is provided, the water capacity to be provided for the crew may be reduced to at least 7 days" supply, or sufficient to cover the longest voyage the ship is expected to undertake, whichever is the less, subject to sub-paragraph (a).

For the temperature of hot water at the ship it is based on Merchant Shipping Notice MSN 1845 (M) Maritime Labour Convention 2006 – Crew Accommodation poin 18 Sanitary Accommodation [**11**] :

18.7 The hot water must be at a constant temperature of at least 66˚C and must be heated by thermostatically controlled calorifiers of adequate capacity or by some equally safe and efficient means.

18.8 Every shower must be provided with an anti-scalding mixing valve which must be set in such a way that the temperature of the shower water can be varied by the person using it to any temperature between the ambient temperature and a temperature of at least:

(i) in the case of a thermostatically controlled mixing valve, 38˚C but not more than 43˚C; or

(ii) in the case of any other mixing valve, 35˚C but not more than 40˚C.

2.12 Heat Balance

To find mass flow rate at Hot Water at storage calorifier we can use this formula from heat balance below :

$$Q_{Hot\ Water} = Q_{Warm\ Water} \quad (2.9)$$

$$\dot{m}_H \times C_p \times \Delta T_H = \dot{m}_W \times C_P \times \Delta T_W \quad (2.10)$$

$$\dot{m}_H = \dot{m}_W \frac{\Delta T_W}{\Delta T_H} \quad (2.11)$$

2.13 Heat Transfer

The log mean temperature difference (LMTD) method is easy to use in heat exchanger analysis when the inlet and the outlet temperatures of the hot and cold fluids are known or can be determined from an energy balance. Once ΔT_{Im} , the mass flow rates, and the overall heat transfer coefficient are available, the heat transfer surface area of the heat exchanger can be determined from

$$\dot{Q} = UA_s\Delta T_{Im} \quad (2.12)$$

Where :

$\dot{Q}$ = Heat released / received (W)

U = overall heat transfer coefficient (W / m^2.^{o}C)

A_s = area of heat transfer in accordance with the definition of U (m^2)

ΔT_{Im} = average temperature difference that is appropriate for use in a heat exchanger (^{o}C)

2.12.1 LMTD

Therefore, the LMTD method is very suitable for determining the *size* of a heat exchanger to realize prescribed outlet temperatures when the mass flow rates and the inlet and outlet temperatures of the hot and cold fluids are specified. With the LMTD method, the task is to *select* a heat exchanger that will meet the prescribed heat transfer requirements. The procedure to be followed by the selection process is:

1. Select the type of heat exchanger suitable for the application.
2. Determine any unknown inlet or outlet temperature and the heat transfer rate using an energy balance.
3. Calculate the log mean temperature difference ΔT_{Im} and the correction factor *F*, if necessary.
4. Obtain (select or calculate) the value of the overall heat transfer coefficient *U.*
5. Calculate the heat transfer surface area A_s .

Before determining the heat surface area (A_s), the first determined value of LMTD. It is based on the difference in temperature of the fluid in and out from the heat.

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)} \quad \text{.........(2.13)}$$

Here ΔT_1 and ΔT_2 represent the temperature difference between the two fluids at the two ends (inlet and outlet) of the heat exchanger. It makes no difference which end of the heat exchanger is designated as the inlet or the outlet.

a. Parallel-flow heat exchangers

$$\Delta T_1 = T_{h,in} - T_{c.in} \quad \text{.........(2.14)}$$

$$\Delta T_2 = T_{h,out} - T_{c.out} \quad \text{.........(2.15)}$$

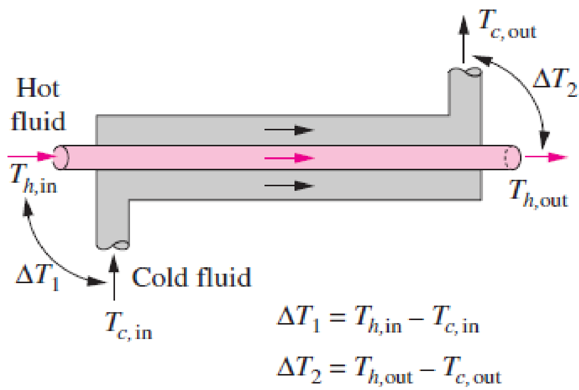

Figure 2. 7 Parallel-Flow Heat Exchanger

b. Counter-flow heat exchangers

$$\Delta T_1 = T_{h,in} - T_{c.out} \quad \text{.........(2.16)}$$

$$\Delta T_2 = T_{h,out} - T_{c,in} \quad \text{.........(2.17)}$$

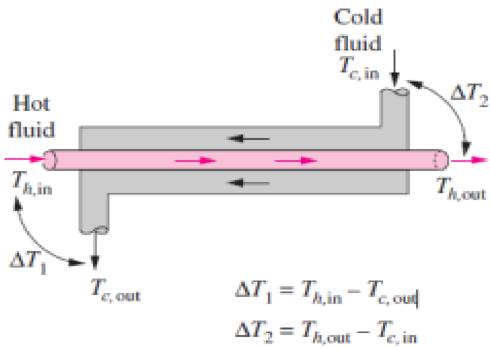

Figure 2. 8 Counter-flow heat exchangers

c. Multipass and Cross-Flow Heat Exchangers:Use of a Correction Factor

Similar relations are also developed for cross-flow and multipass shell-and-tube heat exchangers, but the resulting expressions are too complicated because of the complex flow conditions. In such cases, it is convenient to relate the equivalent temperature difference to the log mean temperature difference relation for the counter-flow case as.

$$\Delta T_{Im} = F\ \Delta T_{Im,CF} \quad \text{.......} \quad (2.18)$$

Where :

F = Correction Factor

$\Delta T_{Im,CF}$ = The log mean temperature difference for the case of a counter-flow heat exchanger with the same inlet and outlet temperatures

$$\Delta T_{Im,CF} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)} \quad \text{.......} \quad (2.19)$$

$$\Delta T_1 = T_{h,in} - T_{c.out} \quad \text{.......} \quad (2.20)$$

$$\Delta T_2 = T_{h,out} - T_{c,in} \quad (2.21)$$

The determination of the heat transfer rate for cross-flow and multipass shell-and-tube heat exchangers using the correction factor. The correction factor is F =1 for both of these limiting cases. Therefore, the correction factor for a condenser or boiler is F=1, regardless of the configuration of the heat exchanger.

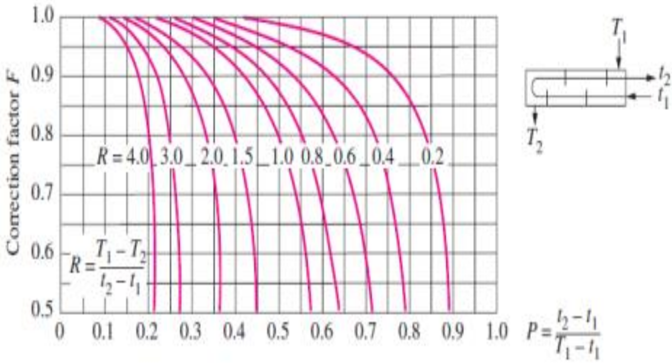

Figure 2. 9 One-shell pass and 2,4,6,etc (any multiple of 2), tube passes

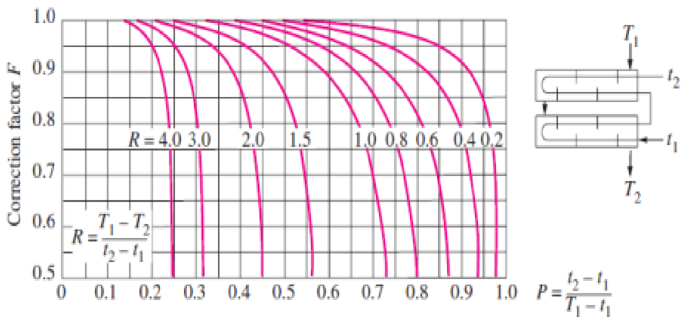

Figure 2. 10 Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes

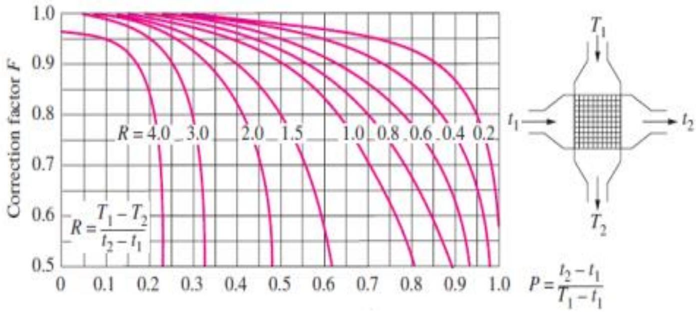

Figure 2. 11 Single-pass cross-flow with both fluids *unmixed*

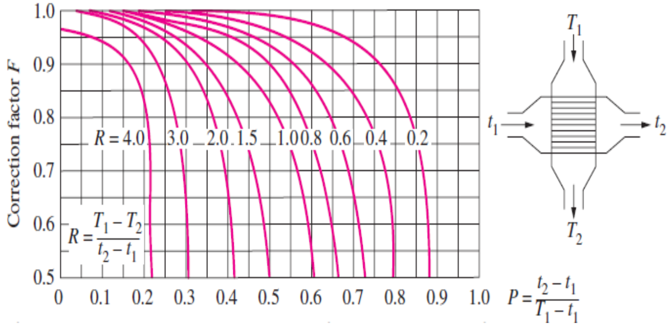

Figure 2. 12 Single-pass cross-flow with one fluid *mixed* and the other *unmixed*

2.12.2 Overall Heat Transfer Coefficient (U)

Heat transfer in a heat exchanger usually involves convection in each fluid and conduction through the wall separating the two fluids. In the analysis of heat exchangers, it is convenient to work with an overall heat transfer coefficient U or a total thermal resistance R, expressed as

$$\frac{1}{UA_s} = \frac{1}{U_iA_i} = \frac{1}{U_oA_o} = R = \frac{1}{h_iA_i} + R_{wall} + \frac{1}{h_oA_o} \quad \text{....................} (2.22)$$

where the subscripts i and o stand for the inner and outer surfaces of the wall that separates the two fluids, respectively. When the wall thickness of the tube is small and the thermal conductivity of the tube material is high, the last relation simplifies to

$$\frac{1}{U} \approx \frac{1}{h_i} + \frac{1}{h_o} \text{......} (2.23)$$

where U≈ Ui ≈ U_o. The effects of fouling on both the inner and the outer surfaces of the tubes of a heat exchanger can be accounted for by

$$\frac{1}{UA_s} = \frac{1}{U_i A_i} = \frac{1}{U_o A_o} = R \text{ ......} (2.24)$$

$$\frac{1}{UA_s} = \frac{1}{h_i A_i} + \frac{R_{f,i}}{A_i} + \frac{\ln(\frac{D_o}{D_i})}{2\pi kL} + \frac{R_{f,o}}{A_o} + \frac{1}{h_o A_o} \text{......} (2.25)$$

where Ai= πDi L and Ao= πDo L are the areas of the inner and outer surfaces and $R_{f,\ i}$ and $R_{f,\ o}$ are the fouling factors at those surfaces.

2.12.3 Heat Transfer Area

To calculate the heat transfer area, can use the following formula:

$$A = \frac{Q}{U \times LMTD \times F_T} \text{ ......} (2.26)$$

$$A = \frac{M_f \times C_f \times (T_1 - T_2)}{U \times LMTD \times F_T} \text{......} (2.27)$$

Where :

A = Heat Transfer Area (ft^2)

M_f = Mass Flow rate (lb/h)

C_f = Coeffisien of Flow rate (btu/lb.^oF)

T_1 = Temperature Inlet (^oF)

T_2 = Temperature Outlet (^oF)
U = Overall Heat Transfer Coeffisien (btu/hr.ft^2.^{o}F)
LMTD = The log mean temperature (^oF)
F_T = Correction factor

2.13 Calculation of Heat Exchanger Performance

Calculation of heat excahanger performance by using the following formulas :

2.13.1 Flow Area

Flow area of shell and tube area can be in the calculation using the following equation:

a. Shell Area

$$A_s = \frac{D \times C' \times B}{144 \times P_t} \quad (2.28)$$

b. Tube Area

$$A_t = \frac{N_t \times A_t}{144 \times n} \quad (2.29)$$

Where :
A_s = Flow area of Shell (ft^2)
D = Inside diameter of Shell (in)
C’ = Distance between the tube (in)
B = Distance between the baffle plate (in)
P_t = Distance between the tube axis (in)
A_t = Flow area of Tube (ft^2)
N_t = Amount of Tube
A_t = Flow area per tube (in^2)
n = Pass Amount

2.13.2 Mass Velocity

Mass velocity of shell and tube can be in the calculation using the following equation:

a. Shell Side

$$G_s = \frac{w_s}{A_s} \text{ .... } (2.30\ )$$

b. Tube Side

$$G_t = \frac{w_t}{A_t} \text{ .... } (2.31)$$

Where :

G_s = Mass velocity at shell side (lb/ft^2.hr)
W_s = Mass velocity of fluid at shell side (lb/hr)
A_s = Flow area of Shell (ft^2)
G_t = Mass velocity at tube side (lb/ft^2.hr)
W_t = Mass velocity of fluid at tube side (lb/hr)
A_s = Flow area of tube (ft^2)

2.13.3 Reynolds Number

The value of the Reynolds number permits us to determine whether the flow is laminar or turbulent. We define the Reynolds number as follows.

a. Shell Side

$$Re_s = \frac{D_e \times G_s}{\mu} \text{ .... } (2.32)$$

b. Tube Side

$$Re_t = \frac{D_e \times G_t}{\mu} \text{...}(2.32)$$

Where :
Re_s = Reynolds number at shell side
G_s = Mass velocity at shell side ($lb/ft^2.hr$)
D_e = Diamater equivalent (ft)
μ = Fluid flow viscocity (lb/ft.hr)
Re_t = Reynolds number at tube side
G_t = Mass velocity at tube side ($lb/ft^2.hr$)
D = Diamater equivalent (ft)

2.13.4 Heat Transfer Factor (jH)

Heat transfer factor on the shell side and the tube can be obtained from the table by using the value of the Reynolds number at figure 2.13 .

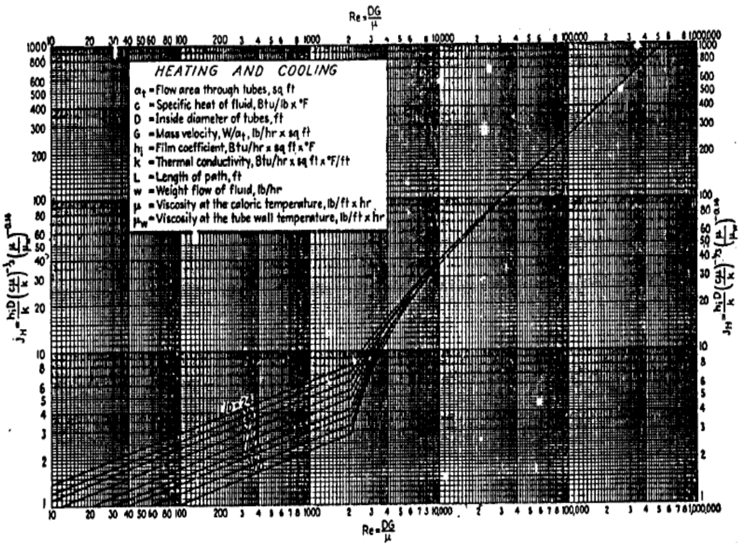

Figure 2. 13 Graphic of Heat Transfer Factor (jH)

2.13.5 Heat Transfer Coeffisien

Heat transfer coefficient on the outside of the tube or the inside of the shell is determined by the formula :

$$\frac{h_o}{\emptyset_s} = jH \times \left(\frac{k}{D_e}\right) \times \left(\frac{c_p \times \mu}{k}\right)^{1/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.33)$$

Where :

Ho = Heat Transfer Coeffisien at side shell (Btu/hr.ft2.Of)
Jh = Heat Transfer Factor at side shell
D_e = Diamater equivalent (ft)
K = Fluid Conductivity inside the shell (Btu/hr.ft2.Of /ft)
μ = Fluid flow viscocity (lb/ft.hr)
Cp = Spesifik heat fluid inside he shell

2.13.6 Clean Overall Heat Transfer Coefficient Design

Clean Overall Heat Transfer Coefficient Design (Uc) is the heat transfer coefficient when the heat exchanger is clean and yet there are deposits or dirt.

$$U_c = \frac{h_{io} \times h_o}{h_{io} + h_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.34)$$

2.13.7 Overall Heat Transfer Coefficient Design

Overall Heat Transfer Coefficient Design is the heat transfer coefficient of heat exchanger which has been operated and already there are deposits or dirt.

$$U_d = \frac{Q_t}{A \times \Delta T_{LMTD}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.35)$$

2.13.8 Dirt/Fouling Factor

Dirt/Fouling Factor is the resistance of heat transfer due to sediment or dirt on the wall when the heat transfer.

$$U_d = \frac{Q_t}{A \times \Delta T_{LMTD}} \text{...(2.35)}$$

2.13.9 Pressure Drop

The value of the pressure drop on the shell side is obtained by the formula:

$$\Delta P_s = \frac{f \times (G_s)^2 \times D \times (N+1)}{(5.22\times10^{10})\times D_e \times s \times \emptyset_s} \text{.. (2.36)}$$

Where :

ΔP_s = Pressure difference between the fluid entrance to the fluid pressure at the exit shell (psi)

F = Friction factor (ft^2/in^2)

G_s = Mass velocity at shell side ($lb/ft^2.hr$)

D = Inside diameter of shell (ft)

N = Amount of baffle

D_e = Diamater equivalent of shell (ft)

S = Specific gravity fluida inside of shell

$\emptyset_s$ = Rasio Viscocity inside of shell

The value of the pressure drop on the tube side is obtained by the formula:

$$\Delta P_t = \frac{f \times (G_t)^2 \times L \times n}{(5.22\times10^{10})\times D \times s \times \emptyset_s} \text{.. (2.37)}$$

Where :

ΔP_t = Pressure difference between the fluid entrance to the fluid pressure at the exit tube (psi)

F = Friction factor (ft^2/in^2)

G_t = Mass velocity at tube side ($lb/ft^2.hr$)

L = the length of the tube (ft)

n = Amount of Pass
D = Diameter inside of the tube
$\emptyset_s$ = Rasio Viscocity inside of tube

2.14 Back Pressure

Back pressure is defined as the exhaust gas pressure that is produced by the engine to overcome the hydraulic resistance of the exhaust system in order to discharge the gases into the atmosphere.Increased back pressure may affect the performance of the turbocharger, causing changes in the air-to-fuel ratio which may be a source of emissions and engine performance problems.All engines have a maximum allowable engine back pressure specified by the engine manufacturer. To prevent the occurrence of back pressure, the calculation by using the following formula and back pressure is allowed does not exceed 10 kPa [**13**]:

$$P = \frac{L \times s \times Q^2 \times 3.6 \times 10^6}{D^5} + P_s \qquad (2.38)$$

Where :
P = Back Pressure (kPa)
L = Total equivalent length of pipe (m)
Q = Exhaust gas flow (m^3/min)
D = Inside diameter of pipe (mm)
Ps = Pressure drop of silencer/raincap (kPa)
S = Density of gas (kg/m^3)

2.15 Heat Insulation Material

Insulation can be defined as a material or combination of materials that will impede the flow of heat. Their insulation can provide several benefits, including saving energy by reducing heat loss, keeping the surface temperature, preventing the flow of steam and condensation on cold surfaces. Thermal insulation is divided into three temperature ranges:

a. Low Temperature Thermal Insulation
   - Cold Water (15^{o}C until 0^{o}C)
   - Refrigeration or glycol (0°C until 75°C)
b. Intermediate Temperature thermal Insulation
   - Hot and steam condensate (16°C until 100°C)
   - Steam (101°C until 315°C)
c. High Temperature Thermal Insulation
   - For *turbine*, *exhaust*, *incenerators*, and *boiler* (316°C until 815°C)

As for the primary insulation material used can be seen in Table 2.1 to 2.3. Materials commonly used as insulation on pipes is a fiber glass pipe insulation covering while the tank is a glass fiber blanket. Glass fiber is often used because it is not flammable, strong and waterproof.

2.16 Pipe Insulation

Basic installation of insulation on pipelines can be seen in Figure 2.14 Cross Section of Insulated Pipe. Heat transfer coefficient of the insulation of pipes can be found using equation (Z. K. Moray, D. D. Gvozdenac, Applied Industrial Energy and Environmental Management) [**14**]:

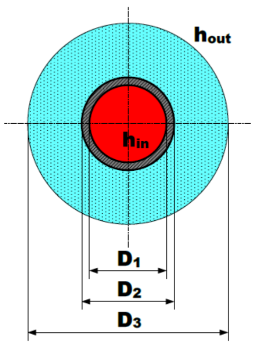

Figure 2. 14 Cross Section of Insulated Pipe

$$U = \frac{1}{\frac{D_3 . ln\left(\frac{D_3}{D_2}\right)}{2.k_{INSULATION}} + \frac{1}{h_{OUT}}} \qquad (2.39)$$

Where :

U	= Heat transfer coeffisien (W/m^2K)
D_3	= Outside diameter of insulation (mm)
D_2	= Outside diameter of pipe (mm)
$K_{insulation}$	= Thermal insulation conductivity (W/mK)
h_{out}	= heat transfer coeffisien of insulation (W/m^2K)

2.17 Heat Loss

To calculate the heat loss can use the following formula :

$$\frac{Q}{L} = \pi \times D_3 \times U \times (T_{in} - T_{out}) \qquad (2.40)$$

Table 2. 1 Material Insulation Low Temperature

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
GLASS CELLULAR	Pipe Covering Block	-268°C to 427°C -450°F to 800°C	.048 (.33) @	4° (40°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C to (850°F) to 538°C to (1000°F) to 538°C to (1000°F)	.035 (.24) @ .032 (.22) @ .030 (.21) @	4° (40°) 4° (40°) 4° (40°)	Good workability, non-combustible, water absorbent. Readily available. Vapour retarder required. Low compressive strength.
ELASTOMERIC FOAM	Pipe Sheet Roll	-40°C to 104°C -40°F to 220°F	.038 (.27) @	10° (50°)	Closed cell good workability, finish not required. Limited thickness to meet flame spread/smoke. Required UV protection.
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.035 (.24) @	4° (40°)	Lightweight, good, workability. Check manufacturers' data. Combustible. Some are treated for fire retardancy. All are closed cell except polystyrene expanded.
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.036 (.25) @	4° (40°)	
POLYURETHANE	Pipe Covering Sheet	-40°C to 107°C -40°F to 212°F	.025 (.18) @	4° (40°)	K-value may change as these materials age. Combustible. High flame spread and smoke.
POLYURETHANE	Pipe Covering Sheet Roll	-70° C to 100°C -94°C to 212°F	.036 (.25) @	10° (50°)	
POLYISOCYANURATE	Pipe Covering Sheet	-183°C to 140°C -297°F to 300°F	.025 (.18) @	4° (40°)	Lightweight, good workability. Check manufacturers' data. Some are treated for fire retardancy. K Values may change with age.

NOTE: Special attention must be given to installation and vapour seal.

*K-Factor Metric = W/m.K (Imperial = Btu.in./h.ft2. °F

Table 2. 2 Material Insulation Intermediate Temperature

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I	to 649°C (1200°F)	.065 (.45) @	93° (200°)	High compression strength, good workability, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
GLASS CELLULAR	Pipe Covering Block Segments	to 427°C (800°F)	.050 (.35) @ .063 (.44) @	24° (75°) 93° (200°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For applications over 204°C (400°F) see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board	to 455°C (850°F) to 538°C (1000°F)	.037 (.26) @ .033 (.23) @	24° (75°) 24° (75°)	Good workability, non-combustible, water absorbent. Low compression resistance.
GLASS FIBER	Blanket	to 538°C (1000°F)	.033 (.23) @	24° (75°)	General purpose material, many facings available.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.037 (.26) @ .037 (.26) @ .037 (.26) @ .048 (.33) @	24° (75°) 24° (75°) 24° (75°) 24° (75°)	Good workability, non-combustible. Water absorbent. Low compression resistance.
PERLITE (Expanded)	Pipe Covering Board	to 649°C (1200°F)	.076 (.53) @	93° (200°)	Good workability, non-combustible. Poor abrasion resistance. Special packaging required to protect materials. Corrosion inhibitor.
ELASTOMERIC FOAM	Pipe Covering-I Sheet-II Roll	-40°C to 105°C -40°F to 220°F	.043 (.30) @	24° (75°)	Closed cell, finish not required, good workability. May require UV protection. Flame spread/smoke limited)
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.037 (.26) @	24° (75°)	Lightweight, excellent workability, combustible although some are treated for fire retardancy (check manufacturers' data sheet for properties) High flame spread/smoke. Check manufacturers' data sheets for values. K value may change as these materials age.
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.039 (.27) @	24° (75°)	
POLYURETHANE	Pipe Covering	-40°C to 105°C -40°F to 225°F	.027 (.19) @	24° (75°)	
POLYETHYLENE	Pipe Covering	-70°C to 100°C -94°F to 212°F	.037 (.26) @	24° (75°)	
POLYISOCYANURATE	Pipe Covering Board	-183°C to 149°C -297°F to 300°F	.027 (.19) @	24° (75°)	Lightweight, good workability. Check manufacturers' data sheets. Some are treated for fire retardancy. K values may change with age

Table 2. 3 Material Insulation High Temperature

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I Type II	to 649°C (1200°F) to 871°C (1600°F)	.087 (.60) @ .101 (.70) @	260° (500°) 260° (500°)	High compressive strength, good cutting characteristics, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
CLASS CELLULAR HIGH TEMP	Pipe Covering Block Segments	to 427°C (800°F)	.103 (.72) @	260° (500°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For application over 204°C (400°F), see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C (850°F) to 538°C (1000°F) to 538°C (1000°F)	.083 (.58) @ .086 (.60) @ .086 (.60) @	260° (500°) 260° (500°) 260° (500°)	Good workability, water absorbent, non-combustible. Check manufacturers' data for specific properties. Low compression resistance.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.072 (.50) @ .092 (.64) @ .101 (.70) @ .101 (.70) @	260° (500°) 260° (500°) 260° (500°) 260° (500°)	Good workability, non-combustible. Low compressive resistance. Water absorbent.
PERLITE (Expanded)	Pipe Covering Block	to 649°C (1200°F)	.106 (.74) @	260° (500°)	Good workability, non-combustible, friable. Check manufacturers' data for specific properties. Poor abrasion resistance. Special packaging required to protect material. Corrosion inhibitor.
CERAMIC FIBER (Refractory Fiber)	Blanket Board	to 1260°C (2300°F) to 1260°C (2300°F)	.086 (.60) @ .080 (.56) @	260° (500°) 260° (500°)	Temperature range varies with manufacturer, style and type.
CEMENTS Hydraulic Setting Cement High Temperature Mineral Wool Finishing Cement (Mineral Fiber or Vermiculite)	Type I Type II Type III	38-649°C (100-1200°F) 38-870°C (100-1600°F) 38-980°C (100-1800°F)	.180 (1.05) @ .160 (1.12) @ .150 (1.26) @	250° (482°) 250° (482°) 250° (482°)	One coat application – insulating and finishing. Slow drying, rough texture – Pointing and insulating and filling. Used over basic insulation – Smooth finish usually 1/8" or ¼" think application.

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CHAPTER 3
METHODOLOGY

The methodology used by author in this thesis is design calculation and design with HTRI Software then it will be compared to determine the performance of the system. When the author made this thesis, of course it require a process to be structured. It must exist, so that in the future the work will be more focused and easier. The phases are as follows and the flow chart diagram at figure 3.1 and be countinued at figure 3.2:

3.1 Identification and Statement of Problems

Identifying the problems are occurred to determine what the problem formulation must be taken. Formulation of the problem is an early stage in the implementation of the thesis. This stage is a very important stage, because the problem in this stage must be solved and it will be used as ingredients for final work. Problem searching is done by digging information about problems that occur at this time. From this stage, the purpose for working in this thesis can be known. In this thesis, the problem to be addressed and solved is the use of technology Calorifier by utilizing the Exhaust gas.

3.2 Literatur Review

After found the problem, the next step is to collect the literature that related to the final project as a reference in the work process. So that the final project does not have similarities with the previous studies.

3.3 Data Collection

At this stage there will be data collecting in the form of information about PKR vessel data that will be used for research object, including general plan images, domestic system images also the number of crew.

3.4 Study Empiris

At this stage there are three main points, that are initial analysis, draft planning, and machining specifications selection that will be used. This initial analysis is used to analyse the waste heat recovery from the main engine exhaust gases. Furthermore, this draft plan is used to plan the system design that will be used, without ignore the safety aspects. Machining specifications must be determined in order to make it easier for the system calculation, system analysis and system design.

3.5 Design System

At this stage there will be system design that suitable for domestic applications in PKR ship using Gas Storage Calorifier Heater application. Where the system is designed according the reference to some certain aspects, such as technical, safety, reability and the convenience factor. Design system devided into two design , that is :

3.5.1 Design System to HTRI

At this stage, HTRI software will be used for design calorifier. This system modelling is made according the design system that has been made in the previous stage**.**

3.5.2 Calculation Design

At this stage, the system will be made by the calculation like heat transfer , flow rate , etc.

3.6 Comparing

At this stage the system that has been designed using HTRI and design by calculation will compared to know the performance of calorifier system.

3.7 Result and Discussion

At this stage the result of the compairation between designed using HTRI and design by calculation , we know how the performance calorifier with utilizing waste heat recovery system

3.8 Conclusions and Recommendations

The final step is to make the conclusion from the whole process that has been done before as well as provide answers to existing problems. The suggestions is given based on the results of the analysis which can become the base of the next research, either directly related to this research or on the data and methodology that will be referenced.

3.9 Flowchart of Research Method

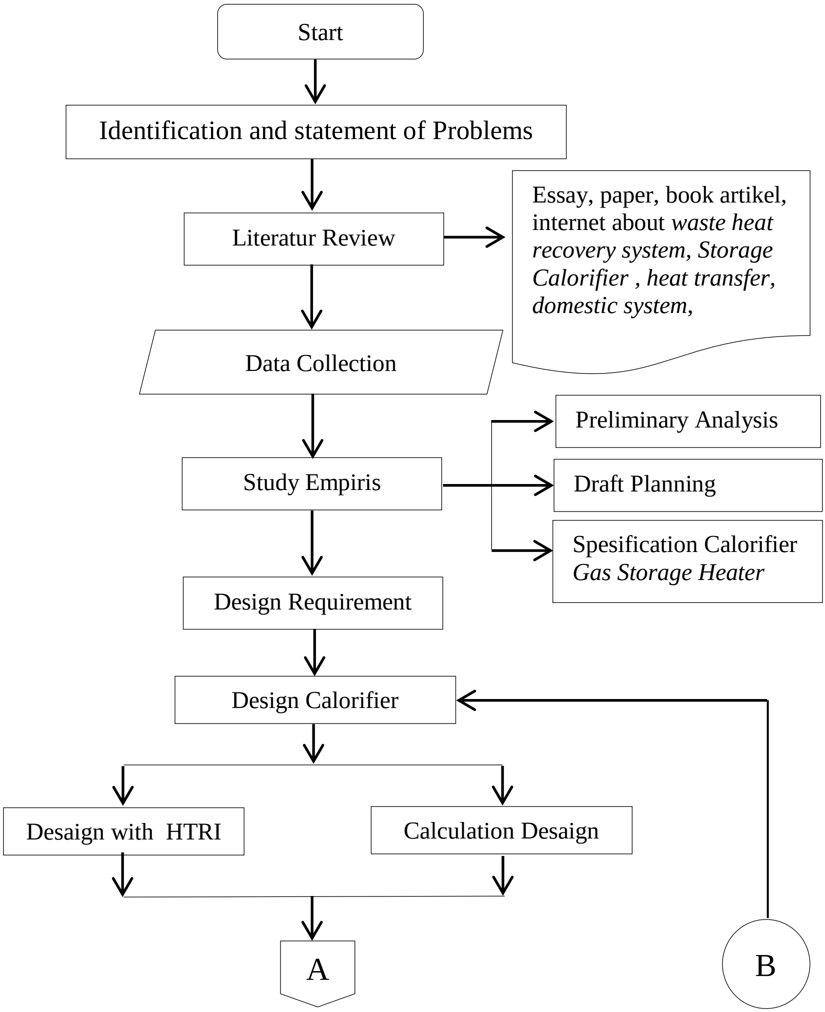

Figure 3. 1 Flowchart of Research Method

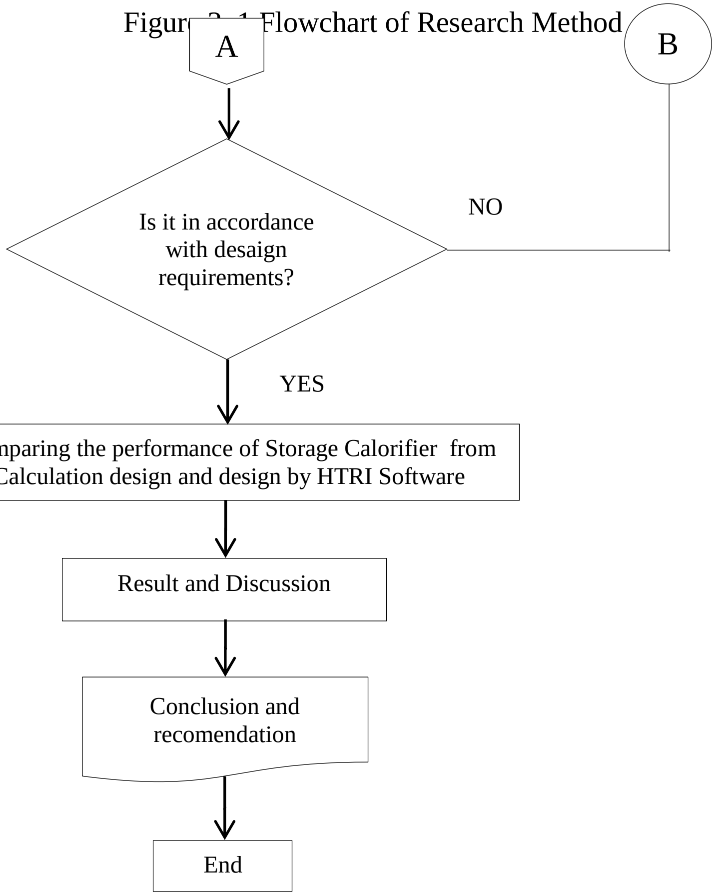

Figure 3. 2 Flowchart of Research Method (Continue)

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CHAPTER 4
DATA ANALYSIS

4.1. Ship Data

The ship which is use for this bachelor thesis is PKR ship from PT.PAL. The ship particular of PKR Ship is described in the table below:

1. Dimension

LOA	= 105,11	m
B	= 14,02	m
H	= 8,75	m
T	= 3,7	m
Displacement	= 2365	ton

2. Performance

Speed (Main Engine)	= 28	knots
Speed (E-Propulsion)	=15	knots
Range at 14 knots	= >5000	NM
Endurance	= > 20	days

3. Propulsion system

Type	= Combined Diesel or Electric (CODOE)
Diesel engine	= 2 x 10000 kW MCR diesel propulsion
Electric motor	= 2 x 1300 kW MCR electric propulsion
Gearbox	= 2 x double input / single output
Propeller	= 2 x CPP diameter 3,65 m

4. Auxilliary systems

Generator	= sets 6 x 771 kWe (CAT C-32A)
Emergency gen. set	= 1 x 180 kWe
FW making capacity	= 2 x 14 m^3/day (RO)

4.2 Design Planning of the Storage Calorifier

Before designing storage calculations, the design arrangement must be done. Design arrangement can make design calculation more easy and accurate. In figure 4.1 below is diagram system storage calorifier.

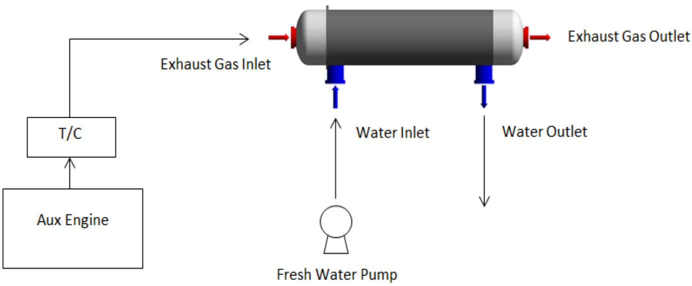

Figure 4. 1 Design Planning of the System Storage Calorifier

In this design planning prefer using resource from Auxilary Engine because if using main engine's exhaust gas would be too much, while exhaust gas from auxilary angine is enought to support the system. To minimize the back pressure potensial, can using the whole auxilary engine is the better option and according to general arrangement of PKR Ship the location of maine engines is further to designed system location than the location of auxilary engine (Diesel Generator room) at figure 4.13.

This PKR Ship operation schedule auxilary engines are more often to use and main engine. The ship will operate about 200 days in port, while at sea propulsion use will be supported by main engine or auxilary engine.

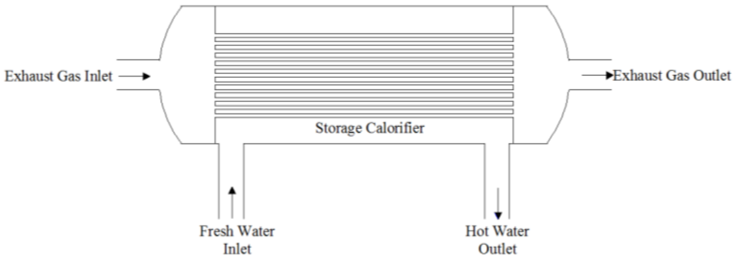

Figure 4. 2 Design Storage Calorifier

In Figure 4.2 is design storage calorifier from inside. This storage will use a tube side single-pass version for minimize the backpressure potensial then the shell and tube exchanger types is Fixed-tube heat exchanger and typical TEMA (Turbular Exchanger Manufactures Association) is BEM for Provides maximum heat transfer area for a given shell and tube diameter, Provides for single tube passes to assure proper velocity, and then Less costly than removable bundle designs.In this design the exhausht through the tubes and the water will through the shell.

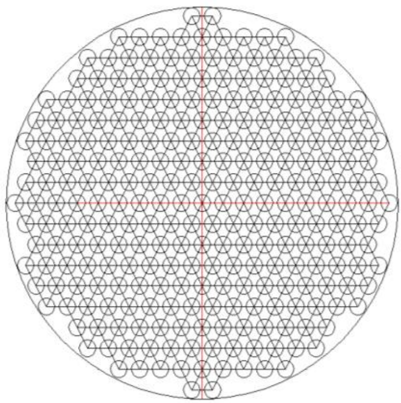

Figure 4. 3 The Tube Layout Planning

The design of the tube layout planning will use the triangular (30^o) to find the amount of the tube, show in the figure 4.3 above. The various types of baffles are shown in Figure 4.4. In case of cut-segmental baffle of 30% .

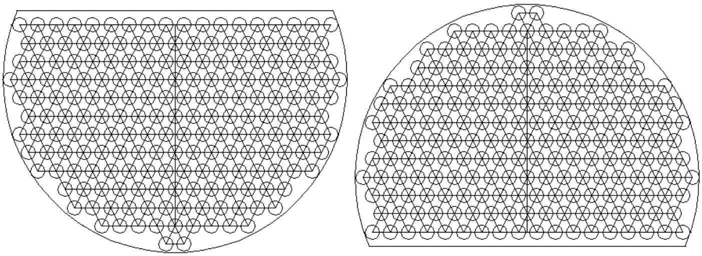

Figure 4. 4 Baffle Cutting Planning

4.3 Data Analysis

Because the data from the auxiliary engine test bed (can be seen in ecnlosure A) is incomplete, so to find the exhaust gas mass flow rate of the auxiliary engine can use the manual calculation below :

4.3.1 Estimating The Auxilary Engine %MCR Based on RPM

The calculation process to find out the RPM at the 50%MCR by using equation 2.4:

$$P_2(\ 100\%\ ) = 771\ \mathrm{KW}$$

$$n_2(\ 100\%\ ) = 1800\ \mathrm{RPM}$$

$$n_1 = \left(\frac{P_1 (n_2)^3}{P_2}\right)^{1/3}$$

$$= \left(\frac{50\ (1800)^3}{100}\right)^{1/3}$$

= 1269,9 RPM

4.3.2 Find Out the KW of Auxilary Engine Certain RPM or Certain %MCR

To find out the kw at certain rpm or certain %MCR of main engine is using a equation 2.5 :

$$kW = Load\ x\ Maximum\ kW\ of\ \text{Auxilary}\ engine$$
$$= 50\%\ x\ 771 \quad KW$$
$$= 391 \quad KW$$

4.3.3 Calculation of Mass Flow Rate From Exhaust Gas Auxiliary Engine

To find out the mass flow rate of exhaust gas is using This equation :

a. Mass Flow Rate of Fuel

$$\dot{m}f = \text{s.f.c x power}$$
$$= 220{,}8 \times 391$$
$$= 81144 \quad gr/h$$
$$= 22{,}54 \quad gr/s$$

b. Intake Air Mass Flow Rate

$$\eta v = \frac{\text{Volume of air}}{\text{Sweft volume}}$$

$$\eta v = \frac{\dot{m}a}{\rho a \times n \times Vs}$$

$$\dot{m}a = \eta v \times \rho a \times n \times Vs$$

Assumption: $Vs = 0{,}321\ m^3$

$\eta v = 3$

$\rho a = 1{,}167\ kg/m^3$

$N = 1800$ rev/min

$\dot{m}a = \eta v \times \rho a \times n \times Vs$

$\dot{m}a = 3 \times 1{,}167 \times 1269{,}9 \times 0{,}032$

$= 142{,}7140$ kg/min

$= 2378{,}5671$ gram/s

c. Mass Flow Rate of Exhaust Gas

$\dot{m}E = \dot{m}f + \dot{m}a$

$= 22{,}54 + 2378{,}5671$

$= 2401{,}107147$ gram/s

$= 2{,}40110$ kg/s

$= 19056{,}7264$ Lb/h

4.3.4 Calculation of The Fresh Water Amount

From Merchant Shipping Act Chapter 179, fresh water of capacity sufficient to provide at least 72 litres per man per day and drinking water of capacity sufficient to provide at least 18 litres per man per day; or. [**15**]

In this calculation author put the assumption 72 liter per man and there are 122 crew at PKR Ship and the amount of fresh water in one day :

The amount of fresh water = 122 X 72

= 8784 liter/days

= 8,784 m^3/days

4.3.5 Calculation of Warm Water Masses

After find the volume of fresh water for a day, and the next calculate mass of warm water at 38^{o}C with this equation :

$m = V \times \rho$ ρ (at temperature 38 ^{o} C) = 992,99 kg/m^3
= 8,784 x 992,99
= 8722,42416 kg/hari

4.3.6 Calculation of Warm Water Mass Flow Rate

From Merchant Shipping Notice MSN 1884 Marine Labour Convention 2006 - Crew Accommodation poin 18 Sanitary Accommodation [**12**] :

Design Temperature System :
Fresh Water Temperature = 25 ^{o}C
Hot Water Temperature = 70 ^{o}C
Warm Water Temperature = 38 ^{o}C

For calculation of warm water masses we can use equation 2.7:

$$\dot{m}_H = \dot{m}_W \frac{\Delta T_W}{\Delta T_H}$$

$$= 8722{,}424 \text{ X } \frac{38 - 25}{70 - 25}$$

$$= 2519{,}811 \quad \text{Kg/hari}$$

$$= 0{,}029164 \quad \text{kg/s}$$

4.3.7 Calculation of Calor Amount for the system

$$\text{Qwater} = m \times c \times (T2 - T1)$$

$$= 0{,}029164 \times 4200 \times (70 - 25)$$

$$= 5512 \quad \text{J/s}$$

$$= 5{,}51208749 \quad \text{KJ/s}$$

$$= 5{,}51208749 \quad \text{KW}$$

4.3.8 Design Storage Calculation

And for the spesification from tube inside the storage in table 4.4 below :

Table 4. 1 Spesification of Tube

OD =	***1,5***	***in***	***=***	***0,125***	***ft =***	***0,0381***	***m***
Lt =	59	in	=	6,5	ft =	1,98	m
Di =	0,834	in	=	0,0695	ft =	0,021184	m
Pt =	1,875	in	=	0,15625	ft =	0,04765	m

Type : 1 ½’’ OD Tubes (12 BWG) on 1 7/8’’ Triangular Pitch

After design system, design storage, and specification tube finished calculating the performance from the storage will be do with this step below.

1. Overall Heat Transfer Coefficient :

$h_1 =$ 800 $W/m^2.^oC$

$h_o =$ 1200 $W/m^2.^oC$

$T_{h,in}$ = 487,4 ^oF

$T_{h,out}$ = 230 ^oF

$T_{c,in}$ = 77 ^oF

$T_{c,out}$ = 158 ^oF

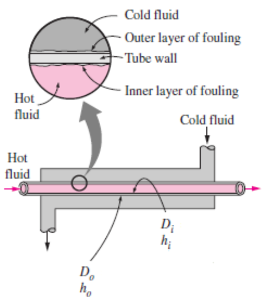

Figure 4. 5 Schematic of Hot fluid and Cold Fluid

$$A_0 = \pi \times D_0 \times L$$
$$= 0{,}23687532\, m^2$$

$$A_i = \pi \times D_0 \times L$$
$$= 0{,}13170267\, m^2$$

$$h_{rad} = \varepsilon\sigma\left(T_{hout}{}^2 + T_{cout}{}^2\right)(T_{hout} + T_{cout})$$
$$= 1 \times 5.57 \times 10^{-8} \times (526{,}15^2 + 383{,}15^2) \times (526{,}15 + 158)$$
$$= 21{,}84162 \frac{W}{m^2}.°C$$

$$R_{conv} = \frac{1}{h_i \times A_i}$$
$$= \frac{1}{800 \times 0{,}13170}$$
$$R_{conv} = 0.00949\ ℃/W$$

$$R_{cond} = \frac{\ln {}^{D_0}/_{D_i}}{2\pi KL}$$

$$= \frac{\ln {}^{0.0381}/_{0.02118}}{2 \times \pi \times 15.1\ X\ 1.98}$$

$$R_{cond} = 0.000.3126℃/W$$

$$R_{conv} = \frac{1}{h_0 \times A_0}$$
$$= \frac{1}{200 \times 0.236875}$$

$$R_{conv} = 0.003518℃/W$$

$$R_{rad} = \frac{1}{h_{rad} \times A_0}$$

$$= \frac{1}{21.841 \times 0.2368}$$

$$R_{rad} = 0.193\ ℃/W$$

$$\frac{1}{R_{conv} + h_{rad}} = \frac{1}{R_{conv}} + \frac{1}{R_{rad}}$$

$$= \frac{1}{0.00351} + \frac{1}{0.193}$$

$$= 284.250 + 5.173$$

$$\frac{1}{R_{conv} + h_{rad}} = 289.424\ W/℃$$

$$R_{conv+rad} = 0.00345\ ℃/W$$

$$R_{total} = R_{conv} + R_{cond} + R_{conv+rad}$$
$$R_{total} = 0.0160℃/W$$

$$U = \frac{1}{R_{tot} + A_{tot}}$$

$$= 37\ \frac{W}{m^2}.℃$$

$$U = 6.5\ \frac{Btu}{hr}.ft^2.℉$$

2. Log Mean Temperature Difference (LMTD)

Because the principle of storage calorifier same with the heat exchanger in this calculation, using the analysis of heat exchanger.In the analysis of heat exchangers, it is usually convenient to work with the logarithmic mean temperature difference LMTD, which is an equivalent mean temperature difference between the two fluids for the entire heat exchanger.

$$\text{LMTD} = \frac{\Delta T1 - \Delta T2}{\ln \frac{\Delta T1}{\Delta T2}}$$

$$\Delta \text{T1} = 487{,}4\text{-}77$$

$$= 410{,}4 \quad {}^{o}\text{F}$$

$$\Delta \text{T2} = 230\text{-}158$$

$$= 72 \quad {}^{o}\text{F}$$

$$\text{LMTD} = \frac{410{,}4 - 72}{\ln \frac{410{,}4}{72}}$$

$$= 235.798 \quad {}^{o}\text{F}$$

3. Heat Transfer Area

$$\text{A} = \frac{\text{Q}}{\text{U X LMTD X F}_\text{T}}$$

$$= \frac{\text{Mf x Cf (T1 - T2)}}{\text{U X LMTD X F}_\text{T}}$$

$$= \frac{19056.7 \text{ x } 0.2472 \text{ (} 410{,}4 - 72)}{6.5 \text{ X } 235.789 \text{ X } 1}$$

$= \quad 640.076 \quad ft^2$

4. The Amount of Tube

$$nt = \frac{A}{\prod x\ Do\ x\ Lt}$$

$= 246$

5. Flow Area Shell

$$a_s = \frac{D_s\ X\ C''\ X\ B}{144\ x\ P_T} \qquad \text{equ. 7.1 , kern}$$

Assumptions :

1. 30% cut segmental baffles
2. Baffle Spacing (B) = 0.5 DS
   = 0.5 x 35
   = 17.5 inc
   = 1.45 ft
3. Diameter inside shell (Ds) = 35 inc
   = 2.91667 ft
4. Tube Pitch (P_T) = 1.875 inc
   = 0.15625 ft
5. Clearance (C’’) = P_T – OD
   = 0.375 inc
   = 0.03125 ft

6. Diameter Outside = 1.5 inc
= 0.125 ft

$$a_s = \frac{35X\ 0.375\ X\ 17,5}{144\ x\ 1.875}$$

= 0.850694 in^2

= 0.005907 ft^2

6. Mass Velocity at Shell

$$Gs = \frac{mf}{a_s}$$

$$= \frac{4409,24}{0.005907}$$

= 746367,39 $lbm/hr.ft^2$

7. Renold Number of Shell

Tc = 77 ^oF

μ = 2,162628 lbm/ft.hr

De = Diametere for the shell side

$$= \frac{4\left({P_T}^2 - \frac{\pi}{4}{d_o}^2\right)}{\frac{1}{2}\pi d_o} = 0,247611$$

$$Re = \frac{De\ x\ Gs}{\mu}$$

$$= 85455,80799$$

8. Corrected Coeffisien of Shell

The value of Thermal conductivity (K) and Spesific Heat (C_p) and Heat Tranfer Factor (Jh) gets from kern chat at temperature 77 ^oF.

K = 0,072 btu/hr.ft.F (Fig. 1 Kern, 1965)

Cp = 0,67 btu/lbm.F (Fig 2 Kern, 1965)

$$jH = \frac{h_o D_e}{k_g}\left(\frac{\mu_g C_g}{k_g}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0,14} \qquad \frac{\mu}{\mu_w} = 1$$

$$190 = \frac{h_o(0,247611)}{0,072}\left(\frac{2,16263x\ 0,67}{0,072}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0,14}$$

ho = 3336,58 btu/hr.ft^2.F

9. Flow AreaTube

at ' = 1,40 in ^{2} (table 10, kern)

$$at'' = \frac{Nt \times at'}{144 \times n}$$

$$= \frac{246 \times 1{,}4}{144 \times 1}$$

= 2.39167 in^2

= 0.0166088 ft^2

10. Mass Velocity at Tube

$$Gt = \frac{w}{at}$$

$$= \frac{19056.72648}{0.011875}$$

= 147387.3 n/hr.ft^2

11. Reynold Number of Tube

tc = 487,4 ^oF

μ = 0,7413 lbm/ft.jam

$$Re = \frac{ID \times Gt}{\mu}$$

= 165099.1239

12. Corrected Coeffisien of Tube

The value of Thermal conductivity (K) and Spesific Heat (C_p) and Heat Tranfer Factor (Jh) gets from kern chat at temperature 483 ^oF.

From Kern's Grafik fig.24 get the value Jh = 300

k = 0,0274 btu/jam.ft^2.F

Cp = 0,252 btu/lbm.F

$$jH = \frac{hiID}{k_g}\left(\frac{\mu_g C_g}{k_g}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0,14} \qquad \frac{\mu}{\mu_w} = 1$$

$$360 = \frac{h_o(0,0695)}{0,0274}\left(\frac{0,7413\ x\ 0,252}{0,0274}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0,14}$$

hI = 269.122 btu/hr.ft^2.F

Hio = hi x ID/OD

= 269.122 X 0,0695 / 0,083

$= \quad 229.650 \quad btu/hr.ft^2.F$

13. Clean Over-all Coefficient

$$Uc = \frac{hio \times ho}{hio + ho}$$

$= \quad 180.996 \quad btu/hr.ft^2.F$

14. Dirt Factor

$$Rd = \frac{Uc - Ud}{Uc \times Ud}$$

$= \quad 0.1483$

Because from Rd Calculation > Rd Convention , 0,148321 > 0,003 ,Then The spesifitication of HE can be approve.

15. Pressure Drop

1. Shell

To find shell-side friction factor to do with put the renould number at shell-side friction factor chart(Figure 29, Kern 1950) and Specific heat can be found at table 6 kern 1950.

Renould Number (Re)	= 85455.80799
shell-side friction factor (f)	= 0,00017 ft^2/in^2
Specific Heat (s)	= 1
Diameter Shell (Ds)	= 2.9167 ft
No. Of Crosses , N+1	= $12 \times \frac{\text{Tube Length}}{\text{Baffle Space}}$

$= 12 \text{ x } \frac{9.8}{1.45}$

$= 81.103$

Total Pressure at Shell (ΔPs) $= \frac{f\ G_s{}^2 D_s\ (N+1)}{5.22\ X\ 10^{10} x\ D_e x \varphi}$

$= \frac{0.00021 x\ 111507{,}21^2 x\ 2.91\ x\ 81.1}{5.22\ X\ 10^{10} x\ 0.247}$

$= 2.3221 \text{ x } 10^{-6}$ psi

$= 1.6 \text{ x } 10^{-5}$ kpa

2. Tube

To find shell-side friction factor to do with put the renould number at shell-side friction factor chart(Figure 29, Kern 1950) and Specific heat can be found at table 6 kern 1950.

Renould Number (Re)	= 165099,1239
shell-side friction factor (f)	= 0.00017 ft^2/in^2
Specific Heat (s)	= 1.29
Tube Length (L)	= 9.8 ft
Amount of Passes	= 1
Diameter Inside (Ds)	= 0.10667 ft

Total Pressure at Tube (ΔPt) $= \frac{f\ G_s{}^2\ L\ n}{5.22\ X\ 10^{10} x\ D_t x\ s}$

$= \frac{0.00017\ x\ 1147387{,}3 x 6.5 x\ 1}{5.22\ X\ 10^{10} x\ 0.10667 x 1.29}$

$= 2.033 \text{ x } 10^{-7}$ Psi

$= 1.4017 \text{ x } 10^{-6}$ Kpa

Mass Velocity (G) = 1604777 lbm/hr .ft^2

$\frac{V^2}{2g}$ = 0.03 (fig.27, Kern 1950)

Return losses (ΔPr) $= \frac{4n}{s}\frac{V^2}{2g}$

$= 9{,}3 \times 10^{-2}$

Total Pressure (ΔP_T) $= (\Delta Pt + \Delta Pr)$

$= 1.4017 \times 10^{-6} + 9.3 \times 10^{-2}$

$= 0{,}093$ Kpa

Bacause Pressure at shell and tube still allowable (ΔP < 10 Kpa) the specification of storage can be approved.

4.3.9 Design Storage Using HTRI Xchanger 6.0

Planning storage calorifier new ones, have been determined by performing various calculations based on a variety of books manual heat transfer. Then, after the manual calculation, then using Xchanger Suite 6.0 software HTRI same input data, the authors conducted a comparative analysis and design of heat exchangers and obtained different results.With the overall data input corresponding to the software manual calculations exchanger HTRI 6.0

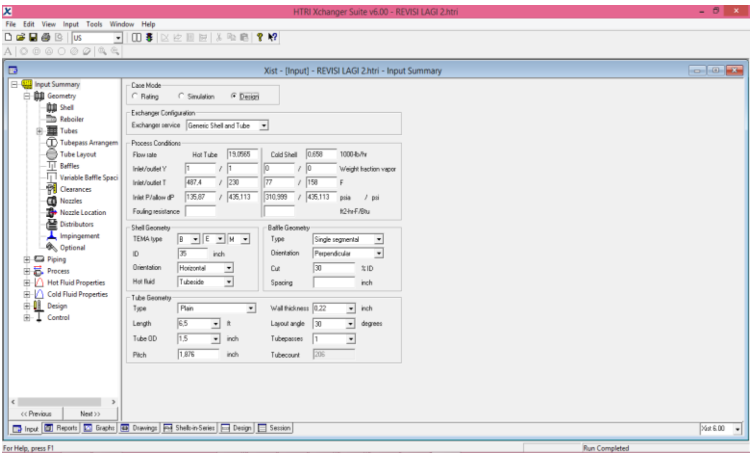

Figure 4. 6 Input Summary HTRI 6.0

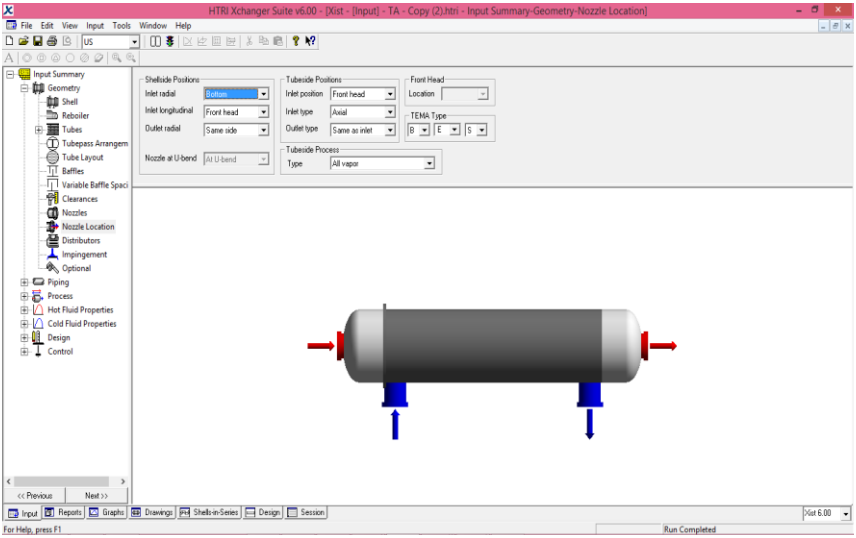

Figure 4. 7 Nozzle Location HTRI 6.0

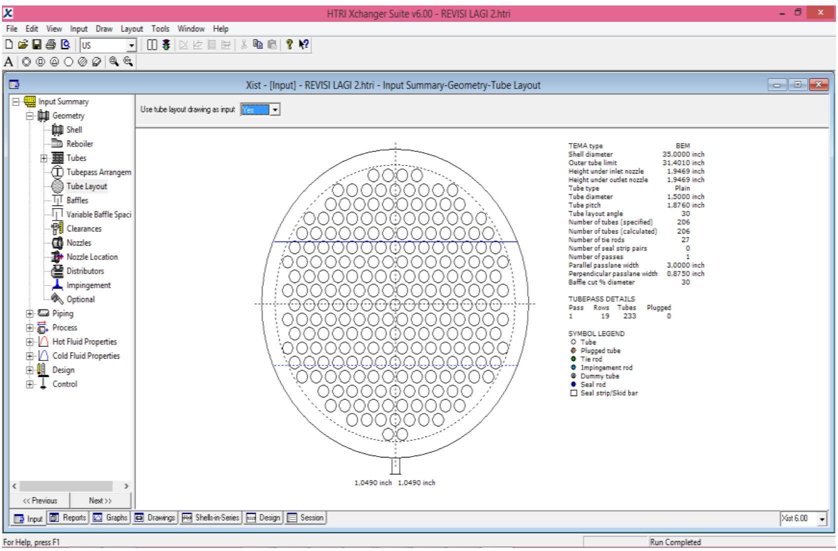

Figure 4. 8Tube Layout

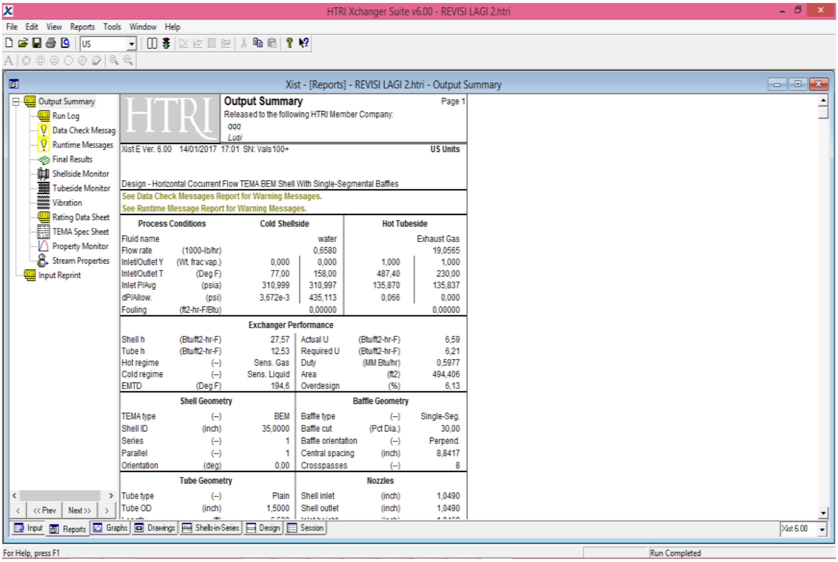

Figure 4. 9 Output Summary HTRI 6.0

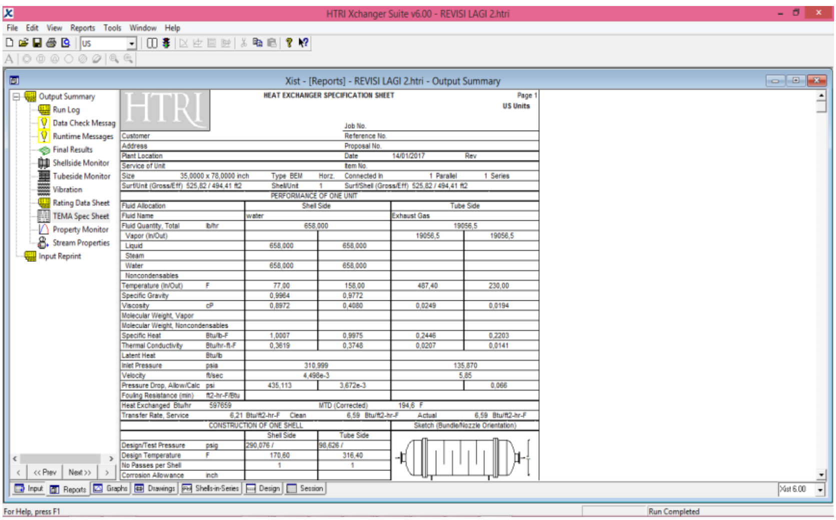

Figure 4. 10 Heat Exchanger Specification Result

Obtained comparison in general the comparison calculation manual and the software:

Table 4. 2 Comparison Calculation Manual and Software

No.	Result	Manual Calculation	HTRI Software
1.	Overall coeficient (Btu/ft2 h F)	6.5	6.96
2.	Area (ft2)	640.076	494.406
3.	Amount of the Tube	246	233
4.	Over Design (%)	6.13 %	

In Comparison of the calculation results to the software manual Heat Exchanger Research Inc. (HTRI) 6.0 with the corresponding input. And the results obtained are not too much difference with the manual calculation.Overdesign represents extra surface area provided beyond that required to compensate for fouling. Typical value of 10% or less is acceptable.Then from the analysis result the overdesign only 6.13% (<10%), so this design is acceptable.

4.3.10 Back Pressure Calculation

$$P = \frac{L \times s \times Q^2 \times 3.6 \times 10^6}{D^5} + Ps$$

$$P = \frac{16.96 \times 0.676 \times 0.144^2 \times 3.6 \times 10^6}{323.9^5} + 0.093$$

$$P = 2{,}40074 \times 10^{-7} + 0.093$$

$$P = 0,09300024\, Kpa$$

Bacause Back Pressure at Exhaust Gas still allowable (ΔP < 10 Kpa) the specification of storage can be approved.

4.3.11 Pipe Insulation

To calculate the heat loss that occurs in the pipeline, which has to do is look for the first heat transfer coefficient. The coefficients can be calculated using a manual calculation below. Is known :

The outer diameter of the insulation (D_3)	= 60	mm
	= 0.06	m
The outer diameter of the insulation (D_4)	= 68	mm
	= 0.068	m
Outside diameter pipe (D_2)	= 0.03	m
Inside diameter pipe (D_1)	= 0.028	m
Pipe material	= Stenless Steal	
Insulation material 1	= Glasswool	
Insulation material 2	= Aluminium Foil	
Conductivity thermal pipe (K_1)	= 32.8	W/m.^{o}C
Conductivity thermal insulation (K_2)	= 0.05	W/m.^{o}C
Conductivity thermal insulation (K_3)	= 235	W/m.^{o}C
Heat transfer coefficient of the insulation (h_2)	= 6.5	W/m^2.^{o}C
Heat transfer coefficient of the pipe (h_1)	= 22	W/m^2.^{o}C
Ambient temperature (T_B)	= 28	^{o}C
Fluid temperature in the pipe (T_A)	= 70	^{o}C

$$R_i = R_{conv}$$

$$R_i = \frac{1}{h_1 \times A_1}$$

$$R_i = \frac{1}{h_1 \times (2 \times \pi \times r \times L\ )}$$

$$R_i = \frac{1}{22 \times (2 \times 3.14 \times 0.014 \times 1\ )}$$

$R_i = 0.5169$ °C/W

$$R_1 = R_{pipa}$$

$$R_1 = \frac{\ln \frac{r_2}{r_1}}{2 \times \pi \times k_1 \times L}$$

$$R_1 = \frac{\ln \frac{0.015}{0.014}}{2 \times 3.14 \times 32.87 \times 1}$$

$R_1 = 0.00033423$ °C/W

$$R_2 = R_{insulasi}$$

$$R_2 = \frac{\ln \frac{r_3}{r_2}}{2 \times \pi \times k_2 \times L}$$

$$R_2 = \frac{\ln \frac{0.03}{0.015}}{2 \times 3.14 \times 0.05 \times 1}$$

$R_2 = 2.2074$ °C/W

$$R_3 = R_{insulasi}$$

$$R_3 = \frac{\ln \frac{r_4}{r_3}}{2 \times \pi \times k_3 \times L}$$

$$R_3 = \frac{\ln \frac{0.07}{0.03}}{2 \times 3.14 \times 235 \times 1}$$

$R_3 = 0.000574$ °C/W

$$R_o = R_{conv}$$
$$R_o = \frac{1}{h_2 \times A_2}$$

$$R_o = \frac{1}{6.5 \times (2 \times 3.14 \times 0.034 \times 1)}$$

$R_o = 0.720523$ °C/W

$$R_{total} = R_i + R_1 + R_2 + R_3 + R_o$$
$$R_{total} = 0.5169 + 0.0003 + 2.2074 + 0.000574 + 0.7205$$
$R_{total} = 3.4454$ °C/W

The calculation of heat loss per meter :

$$\dot{Q} = \frac{T_1 - T_2}{R_{total}}$$

$$\dot{Q} = \frac{70 - 28}{3.44}$$

$\dot{Q} = 12.190$ W

$$\dot{Q} = \frac{m \times c \times \Delta T}{24x3600}$$

$$12.190 = \frac{2519.8 \times 4200 \times (70 - T_2)}{24x3600}$$

$$0.0995 = (70 - T_2)$$
$$T_2 = (70 - 0.0995)$$
$$T_2 = 69.9\ ^{o}\mathrm{C}$$

4.3.12 Operational System

Operational of Exhaust System on the storage calorifier system will work as explained below and at figure 4.8 :

1. When Temperature indicator detecting a decreasing in temperature below 158^{o} F the temperature indicator (TI) will send a signal to the control box to open the lift check valve so the exhaust gas enter the storage calorifier and water re-heated.
2. But when the water temperature in storage calorifier exceeds 70^{o}C then temperature indicator automatically will send a signal to the control box to close the check valve lift and open the lift check valve at bypass exhaust manifold system.
3. A decreasing in the storage temperature due to the heat loss during the water is not used for a longer period or due to additional volume of incoming fresh water when the water level drops.

Water operational on a storage calorifier system will work as explained below and at figure 4.11:

1. When the hot water is used, the water level in the storage will be decreased so that the Level Alarm Low (LAL) will detect the drop in water level especially at 2.6 m^3 and send a signal to the control box to open the valve and turn on the pump.
2. After Fresh water pump have filled the water until full the level alarm will detect high water level especially at 8,37 m^3. Level Alarm High (LAH) will send a signal to the control box to close the valve and shut off the pump.

3. Back flow system will be activated when the hot water temperature have decreased coming out from the pump. Temperature indicator (TI) will detect a drop in temperature and sends a signal to the control box so that the valve on the back flow open and the water will flow back into the fresh water tank or re-enter on a storage calorifier.

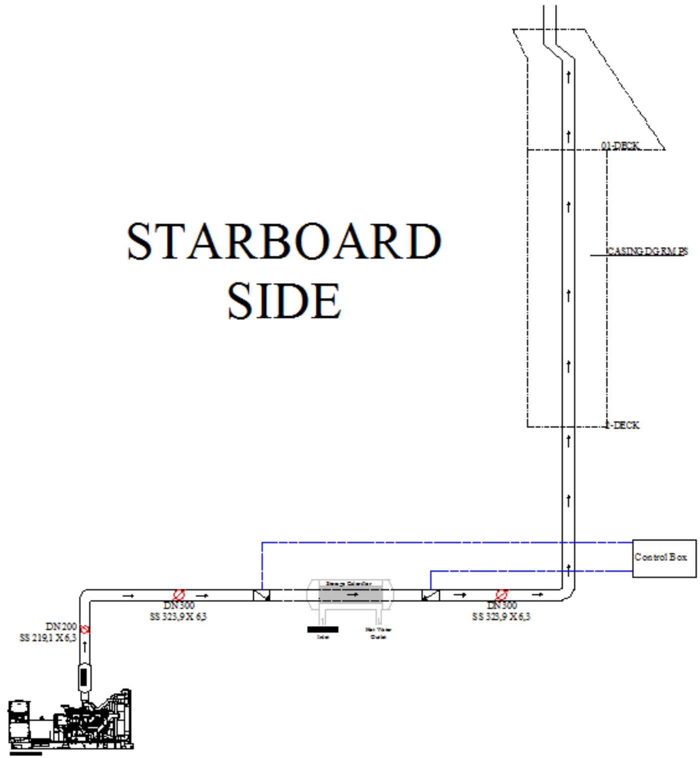

Figure 4. 11 Operational of Exhaust System on a storage calorifier from starboard side

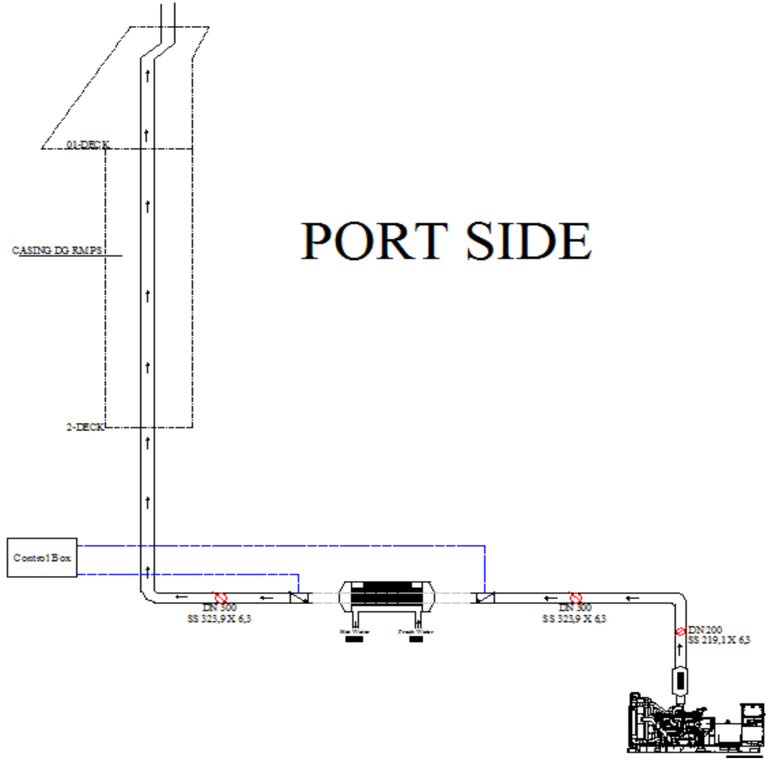

Figure 4. 12 Operational of Exhaust System on a storage calorifier from Port Side

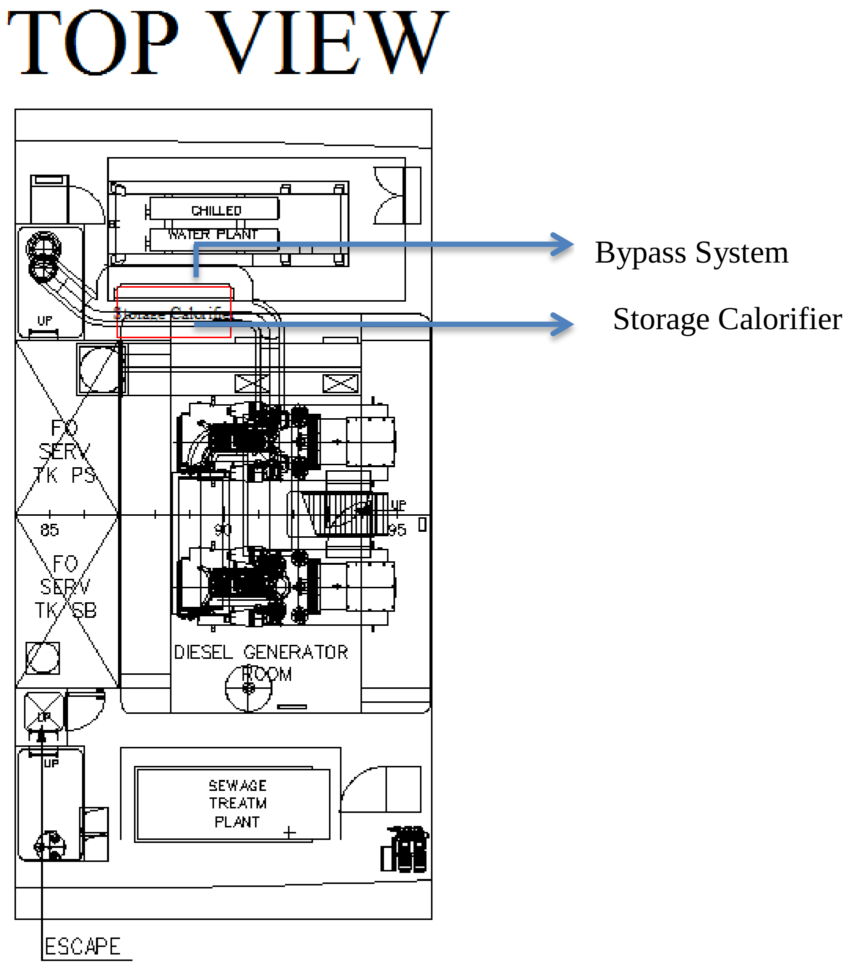

Figure 4. 13 Operational of Exhaust System on a storage calorifier from top view

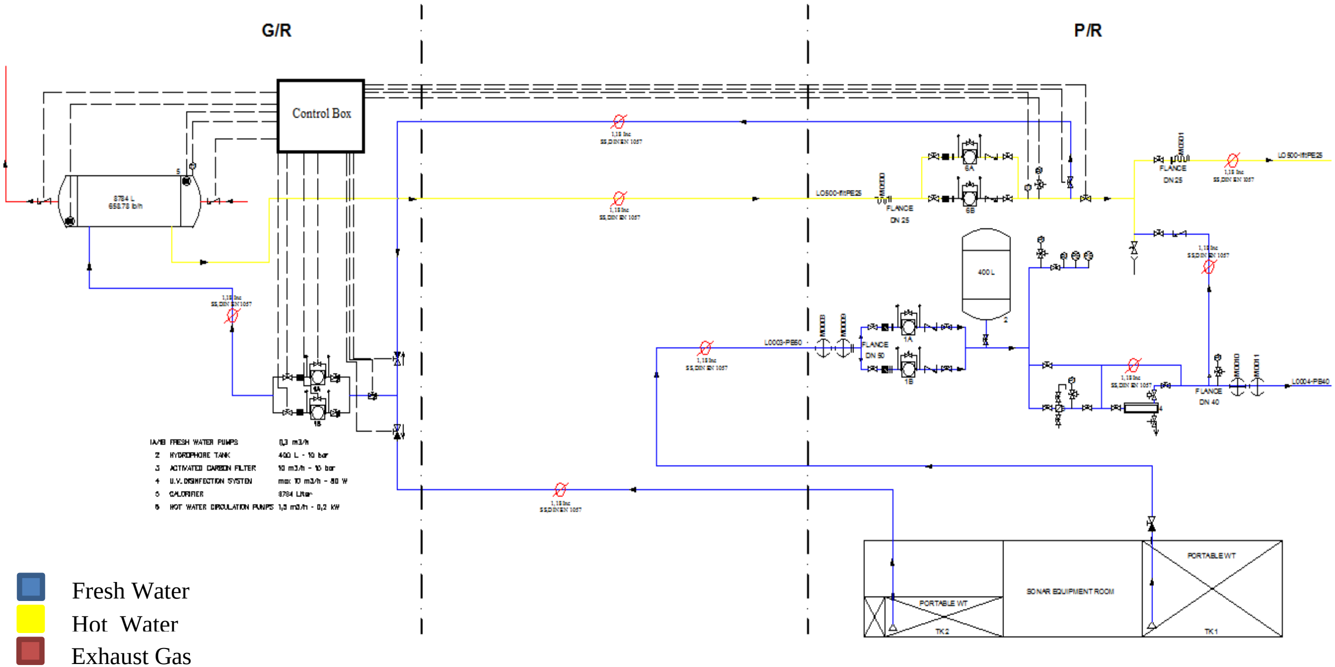

Figure 4. 14 Water operational on a storage calorifier system

4.3.13 Economic Analysis

4.3.13.1 Storage Calorifier System Equipment Price

List of Storage Calorifier System equipment are gathered from supplier manufacturers information (For the specification of equipment can be seen in ecnlosure b) and some equipment price data are gathered from estimation using website for the estimation.

Table 4. 3 Price of Storage Calorifier system Equipment

Equipment	**Manufactures**	**Type**	**Price ($)**
Shell Tube Heat Exchanger			1000
Lift Check Valve	Global Beijing Import and Export Co., Ltd	SS304	200
Control Valve	Westlock Controls Corp	2007xn-by-e45	110
Centrifugal Pump	EBARA	150X125 FS4J522	250
Butterfly Valve	Apollo Valve	LD14102BN11 LD14102BN11	130.31
Non-Return Valve	Zhejiang Lonze Valve Co., Ltd.	H44	250
Strainer	Vetus Marine	330	93.75
Tank High/Low Level Alarm	Gizmo	THL/TLL	179.00
Temperature Indicator	Gaimc	GTC701	108
Pressure Indicator	Yudian	AI-500	36.9
Pipe Insulation	DDL	DDL-R	1

After the list price of the equipment, the next is a list of the amount of equipment required in the new system.

Table 4. 4 Total Price of Storage Calorifier system Equipment

Equipment	Equipment Price ($)	Amount	Total Equipment Price ($)
Shell Tube Heat Exchanger	1000	1	1000
Lift Check Valve	200	4	800
Control Valve	110	13	1430
Centrifugal Pump	230	2	460
Butterfly Valve	130.31	4	521.24
Non-Return Valve	250	5	1250
Strainer	93.75	2	187.5
Tank High/Low Level Alarm	179.00	2	358
Temperature Indicator	108	1	108
Pressure Indicator	36.9	4	147.6
Pipe Insulation	1	250 m	250

According to the "Cost and Project Engineering Handbook" the maintenance cost is approximated 10% from the price of each equipment's and the installation cost of each equipment estimated to be 20% of static equipment (valve, control valve, Strainer,LAH,LAL,TI,PI) and 25% of rotary equipment H/E, pump) (Humphreys, 2006). The list of maintenance and installation cost are listed below:

Table 4. 5Storage Calorifier System Equipment Maintenance & Installation

Equipment	Total Equipment Price ($)	Maintenance Cost ($)	Installation Cost ($)
Shell Tube Heat Exchanger	1000	100	250
Lift Check Valve	800	80	160

Equipment	Total Equipment Price ($)	Maintenance Cost ($)	Installation Cost ($)
Control Valve	1430	143	286
Centrifugal Pump	460	46	115
Butterfly Valve	521.24	52.124	104,248
Non-Return Valve	1250	125	250
Strainer	187.5	18.75	37.5
Tank High/Low Level Alarm	358	35.8	71,6
Temperature Indicator	108	10,8	21.6
Pressure Indicator	147.6	14.76	29.52
Pipe Insulation	250	25	50
Total Price ($)	6512.3	651,2	1375.46

Total price for re-design hot water system in PKR ship need \$8539.04. that is for new equipment, maintenance new system and for instalation.

4.3.13.2Cost Saving in Auxilary Engine Fuel

Specific fuel oil consumption data from specific auxiliary engine can be obtained from the project guide of its engine. The SFOC (Specific Fuel Oil Consumption) data for typical auxiliary engine load is figured at table 4.6:

Table 4. 6 SFOC of the auxiliary engine

%MCR	Pi (kW)	SFOC (g/Kw.h)
10	77.1	214,58
20	154.2	210,46
25	192.75	209,075
30	231.3	208,14

%MCR	Pi (kW)	SFOC (g/Kw.h)
40	308.4	207,62
50	391	208,9
60	462.6	211,98
70	539.7	216,86
75	581	219,975
80	616.8	223,54
90	693.9	232,02
100	771	242,3

After the installation of the calorifier the calculation shows that there are certain amount of fuel saving due to decreasing of the load compared with the existing system. The specific amount of fuel saving can be calculated by using engine specific %MCR x SFOC graph figure 4.15 below. The point that shows the equilibrium position of engine load and SFOC can be considered as new SFOC point of the generator after installation of calorifier.

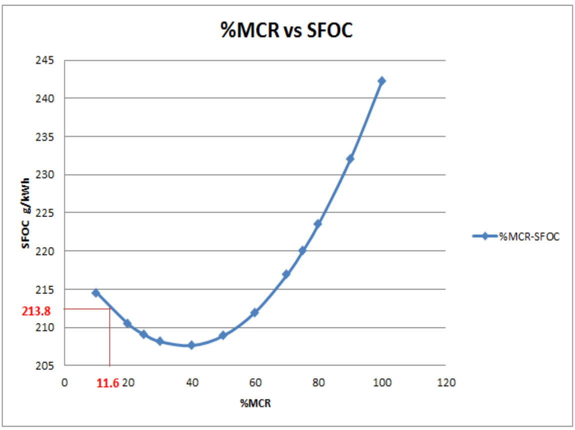

Figure 4. 15 Grafic of %MCR vs SFOC

As shown in graphic the new %MCR vs SFOC point (shown by red typing) are one example of the calculation. The complete calculation of SFOC vs Load calculation can be seen in the following table 4.7.

Table 4. 7 Power, %MCR ,SFOC after adding the storage calorifier

Po (KW)	**% MCR**	**SFOC**
18,13	2,4	218,95
95,23	12,4	213,45
133,78	17,4	211,38
172,33	22,4	209,75
249,43	32,4	207,86
332,03	42,5	207,77
403,63	52,4	209,46
480,73	62,4	212,97
522,03	67,4	215,41
557,83	72,4	218,27
634,93	82,4	225,37
712,03	92,4	234,28

Table 4.7 above show the fluctuation of SFOC at various load after reduction of the existing system using calorifier system.From the table at 1.6%MCR not possible to the auxilary engine to running at that point. The FOC (Fuel Oil Cunsumption) before storage calorifier added at the 50%MCR for 1 day can be determined as the calculation below:

FOC = SFOC x Power x Hr (Duration)
= 212.89 x 391 x 24
= 1997.76 kg/day

By using the similar process and calculation, the complete result for fuel saving at table 4.8 below:

Table 4. 8 Fuel oil consumption before storage added

%MCR	P (KW)	SFOC (g/Kw.h)	FOC (kg/day)
10	77,1	214,58	397,06
20	154,2	210,46	778,87
25	192,75	209,075	967,18
30	231,3	208,14	1155,43
40	308,4	207,62	1536,72
50	391	208,9	1960,32
60	462,6	211,98	2353,49
%MCR	**P (KW)**	**SFOC (g/Kw.h)**	**FOC (kg/day)**
70	539,7	216,86	2808,94
75	581	219,975	3067,33
80	616,8	223,54	3309,11
90	693,9	232,02	3863,97
100	771	242,3	4483,52

For the Fuel Oil Consumption of the auxiliary after adding the storage calorifier by using the similar process and calculation, the complete result for fuel saving at table 4.9 below:

Table 4. 9 Fuel oil consumption after storage added

%MCR	P (kW)	SFOC (g/Kw.h)	FOC (kg/day)
18,13	2,4	218,95	95,27
95,23	12,4	213,45	487,84
133,78	17,4	211,38	678,67
172,33	22,4	209,75	867,52
249,43	32,4	207,86	1244,29

%MCR	P (kW)	SFOC (g/Kw.h)	FOC (kg/day)
332,03	42,5	207,77	1655,64
403,63	52,4	209,46	2029,09
480,73	62,4	212,97	2457,10
522,03	67,4	215,41	2698,83
557,83	72,4	218,27	2922,17
634,93	82,4	225,37	3434,29
712,03	92,4	234,28	4003,47

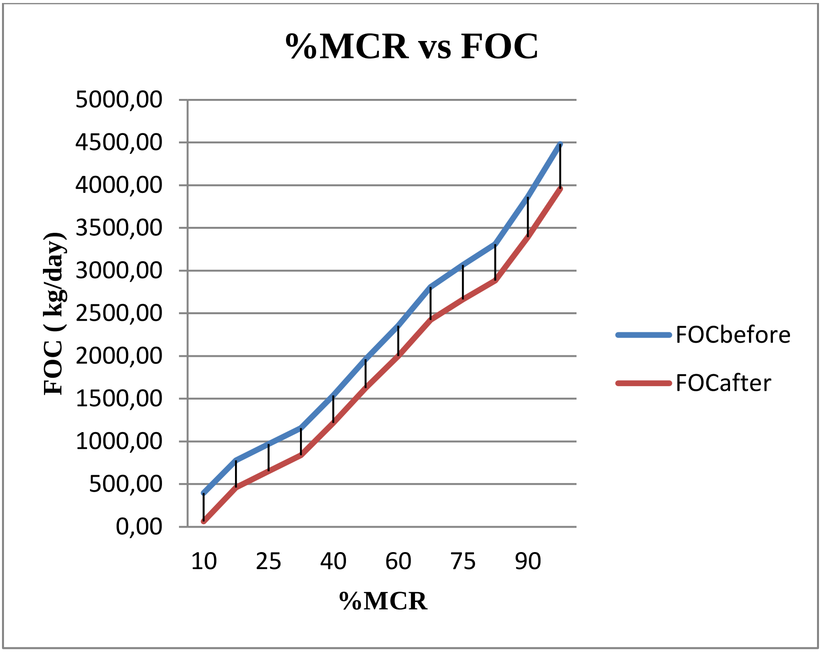

Figure 4. 16 Grafic of %MCR and FOC after-before adding the storage

After added the storage calorifier can be reduced the fuel oil consumption of the auxiliary engine load at Figure 4.16, then the fuel oil savings of the auxiliary engine load per days are :

Fuel Oil savings = $FOC_{before} – FOC_{after}$
= 1997,76 – 1665,65
= 332.11 kg/day

By using the similar process and calculation, the complete result for fuel saving at table below:

Table 4. 10 Fuel oil saving after storage calorifier added

%MCR$_{before}$	**%MCR$_{after}$**	**Fuel Oil Saving (kg/day)**
10	2,4	301,79
20	12,4	291,03
25	17,4	288,51
30	22,4	287,91
40	32,4	292,43
50	42,5	304,67
60	52,4	324,40
70	62,4	351,85
75	67,4	368,50
80	72,4	386,94
90	82,4	429,67
100	92,4	480,05

Then after 1 year the storage calorifier operated, the fuel that can be saved are :

Fuel Oil Saving = Fuel saving x Duration
= 304.67 x 365
= 111205.87 kg/year

The ship is using MDO as a fuel for auxiliary engine, therefore the density of the fuel is 843 kg/m^3.

To calculate the liters saving per year is figured below:

$$V = \frac{m}{\rho}$$

$$V = \frac{111205{,}8}{843}$$

$V = 139.659$ m^3/years

$V = 139659$ liter/years

By using the similar process and calculation, the complete result for fuel saving at table below:

Table 4. 11 Fuel Saving per year

% MCR$_{before}$	**%MCR$_{after}$**	**FOC (kg/years)**	**liters saving (liter/years)**
10	2,4	110153,73	130669
20	12,4	106225,11	126008
25	17,4	105306,86	124919
30	22,4	105086,00	124657
40	32,4	106736,42	126615
50	42,5	111205,87	131917
60	52,4	118405,79	140458
70	62,4	128424,76	152343
75	67,4	134502,86	159553
80	72,4	141233,24	167536
90	82,4	156831,24	186039
100	92,4	175218,75	207851

After know how much fuel oil that can be saved per years, then calculated the price of fuel saving per year. Assumed in every years the price of MDO will grow 10% from the previous year and the dollar price is to be locked at Rp. 13.000,00 per US Dollar. the MDO price increase can be seen in the table below:

Table 4. 12 MDO Price every year

Year	MDO price per liter (IDR)	MDO price per liter ($)	Profit ($)
2017	Rp8.799	$0,677	$110.349
2018	Rp9.679	$0,745	$121.384
2019	Rp10.647	$0,819	$133.522
2020	Rp11.711	$0,901	$146.874
2021	Rp12.883	$0,991	$161.562
2022	Rp14.171	$1,090	$177.718
2023	Rp15.588	$1,199	$195.490
2024	Rp17.147	$1,319	$215.039
2025	Rp18.861	$1,451	$236.543
2026	Rp20.748	$1,596	$260.197
2027	Rp22.822	$1,756	$286.217
2028	Rp25.105	$1,931	$314.838
2029	Rp27.615	$2,124	$346.322
2030	Rp30.377	$2,337	$380.955

Based on the calculation above, considering the capitals that is related to puchasing cost, maintenance cost, and instalation cost. Payback period can be achived in calculation below:

Table 4. 13 Payback Period

Explanation	2016	2017	2018	2019	2020
Equipment	-$6.512	-	-	-	-
Installation	-$1.375	-	-	-	-
Maintenance	-	$651	$716	$788	$866

Explanation	2016	2017	2018	2019	2020
Saving Fuel	-	$100.318	$110.350	$121.385	$133.523
Profit	**-$7.888**	**$99.667**	**$109.634**	**$120.597**	**$139.363**
Explanation	**2021**	**2022**	**2023**	**2024**	**2025**
Equipment	-	-	-	-	-
Installation	-	-	-	-	-
Maintenance	$953	$1.048	$1.153	$1.269	$1.395
Saving Fuel	$146.875	$161.563	$177.719	$195.491	$215.040
Profit	**$153.299**	**$168.629**	**$185.492**	**$204.042**	**$224.446**
Explanation	**2026**	**2027**	**2028**	**2029**	**2030**
Equipment	-	-	-	-	-
Installation	-	-	-	-	
Maintenance	$1.535	$1.689	$1.857	$2.043	$2.247
Saving Fuel	$236.544	$260.199	$286.219	$314.841	$346.325
Profit	**$246.890**	**$271.579**	**$298.737**	**$328.611**	**$361.472**

The scenario for the economy calculation above the maintenance cost will increase 10% every years and for maintenance cost start if the storage calorifier start the operation. In this thesis, it is assumed that the oprational of PKR ship will be began at begining of 2017. According to my economic calculation, its turns out that the payback period is about 1 year, exactly at around the end of 2017.

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CHAPTER 5
CONCLUSION & SUGGESTION

5.1 Conclusion

Based on data analysis and result which has been done in the previous section, conclusion can be concluded as follows:

5.1.1 Technical Analysis

1. The amount of required exhaust gas for heating the 8.784 m3/day of fresh water until temperature constant at 158^{o}F is 19056.72648 lb/h.
2. From the Comparison of the calculation results between the manual calculation and software of Heat Exchanger Research Inc. (HTRI) 6.0 with the corresponding input, it is not much with the manual calculation. From manual calculation the area is 640.076 ft^2 while the area from HTRI software is 494.406 ft^2. Overall coefficient from manual calculation is obtained 6.5 btu/ft^2.h.F and from HTRI software is 6.96 btu/ft^2.h.F. Over design from calculation manual and htri software is 6.13 % , it is acceptable because the value is less than 10%, which is the maximum value of over design.
3. The result value of the back pressure is still allowed if the value is less than 10 kPa. From calculation the value of back pressure is 0.09300024 kPa. It means that the system is still allowed ($\Delta P < 10$ Kpa) and the specification of storage can be approved.
4. The operational of storage calorifier operasional depends on temperature and the level of water. If the temperature of water is below 158^{o} F the exhaust gas valve will be opened and re-heating the water, but when water temperature above 158^{o}F

the exhaust gas valve will be closed because the actual water tempurature already achieved the required temperature. Then when the water level in storage calorifier below the minimum amount, level alarm low will send the signal to control box to re-open the valve to fill the storage calorifier and when the water at storage calorifier is achieved the maximum amount the valve will be closed.

5.1.2 Economic Analysis

1. Based on the economic analysis for redesign hot water in domestic system of PKR ship, it needs $94196.74 and for maintenainace needs $9419.674 then for instalation new system needs $21349.07. After using storage calorifier for heating the water, the fuel oil consumption (FOC) of auxilary at 50%MCR is 1319179 liter/year. So if operations are assumed to begin in early 2017, at the end of 2017 the primary capital to re-design can be returned.

5.2 Suggestion

As for suggestions which can be deliver incorrelate with this bachelor thesis and for the further improvement of this research are:

1. Necessary analysis in terms of safety because of the adjacent placement of storage calorifier with auxiliary engine. so the storage calorifier can work function in PKR ship safely.

REFERANCE

[1] P.S Nargesh , "Pollution and Human Health ," *International Journal of Research Granthaalayah* , vol. 3, September 2015.

[2] Axel Lutten Berger, Biserka Rukavina , and Loris Rak , "Challengs in Regulating the Air Pollution from Ships ".

[3] Nam Dong , "Hot To Reduce Emission of Nitrogen Oxides from Marine Diesel Engines in relation to Annex VI of MARPOL 73/78 ," *The Maritime Commons: Digital Repository of the World*, 2000.

[4] MAN Diesel Turbo , "Waste Heat Recovery System (WHRS) for Reduction of Consumption, Emission and EDDI".

[5] J.S Jandhao D.G Thombare, "Reviwe on Exhaust Gas Recovery for I.C.Engine," *International Journal of Engineering and Innovative Technoloty* , June 2013.

[6] Jones , *Tolley's Domestic Gas Installation Practice*.: Routes One Ltd, 2008.

[7] I Bizzy and R Setiadi , "Studi Perhitungan Alat Penukaran Kalor Tiper Shell and Tube dengan Program Heat Transfer Research.Inc (HTRI)," Jurusan Teknik Mesin, Fakultas Teknik, Universitas Sriwijaya, 2013.

[8] Dig Vinjay Singh and Eilif Pedersen, "A review of waste heat recovery technologies for maritime applications ," *Elsevier*, December 2015.

[9] MAN Diesel, "Thermo efficiency system for reduction of fuel consumption and CO2," 2014.

[10] K Kuiken, "Diesel engine for ship propulsion and power plants-I," vol. 1, 2008.

[11] "Maritime Labour Convention ," in *International Labour Conference*, 2006, p. 41.

[12] "Merchant Shipping Notice ," in *Maritime & Coastguard Agency* , 1845 (M).

[13] CAT , "Application and Installation Guide "Exhaust System "".

[14] D.D. Gvozdenac Z.K.Moray, *Applied Industrial Energy and Environmental Management*.

[15] *Merchant Shipping Act*., 1996, ch. 179.

[16] Kib Angga Royani, "Perencanaan Sistem Pemanfaatan Panas Buang Untuk Pemanas Air Pada Sistem Domestik MT.VANDA," Institute Technology Sepuluh November , Surabaya, 2015.

[17] Handy Pratama, "Design Storage Tank," Institut Mechanical Engineering, Bandung, 2014.

[18] Cleghom Waring, "Choosing and Installing Water storage".

[19] Christian Gunawan, "Perancangan Thermal Penukar Panas ," 2010.

[20] Mayer A, "Number-based Emission limits VERT-DPF-Verfication Procedure and Experience with 8,000 Retrofits," Switzerland, 2004.

[21] Akram Faisal, "Technical Economic Analysis of Organic Rankine Cycle System Using Low-Temperature Source and Refigerant Liquid as Working Fluid to Generate Electricity in Ship," Institute Technology Sepuluh November, Surabaya, 2016.

[22] Yunus A Cengel, *Heat Tranfer* , 2nd ed.

[23] Q Donald Kern, *Process Heat Transfer*.: Profisiona; ;ecturer in Chemical Engineering Case Institute of

Technology, 1965.

[24] Bagus Putranto, "Perencanaan Concentric Tube Heat Exchanger Dalam Pemakaian Khusus di Laboratorium," *Undergraduate Thesis of Mechanical Engineering*, 1989.

[25] V Mallikarjuna, N Jashuva, and Bhupal Rama Reddy, "Improving Effeciency By Using Air Preheater," *International Journal of Advanced Research in Engineering and Applied Sciences*, 2014.

[26] Mustaza Ma'a, "Karateristik Perpindahan Panas pada Double Pipe Heat Exchanger, perbandingan parallel dan counterflow," *Jurnal Teknik Elektro dan Komputer Program Studi Teknik Mekatronika, Politeknik Caltex Riau*, 2013.

[27] Djoko Sriyono, H Nukiandi, and Iwan Mahindra, "Menuju Redesign Air Heater," *Perpustakaan Up Gresik PT. PJB-Gresik*, 2007.

[28] Frank P Incropera, David P Dewitt, Theodore L Bergman, and Adrienne S Lavine, *Fundamentals of Heat and Mass Transfer*.: John Wiley & Sons, 2007.

[29] Jeffrey B Williams, Thomas Walter, and Han Dong-Hoon, *Double Pipe Heat Exchanger*.: University Of Utah, Department Of Chemical Engineering, 2002.

[30] Mohammad Shafiq, "Design Small Heat Exchanger (Double Pipe Type)," *Universiti Malaysia Pahang, Faculty of Mechanical Engineering*, 2010.

[31] Evioplus. (2015, November) Heat Exchanger : Design,Operation, Maintenace, And Troubleshooting. [Online]. http://Evioplus.com/Heat-ExchangerDesignoperationmaintenance-

And_Troubleshooting/>

[32] Awwaluddin Muhammad, "Analisis Perpindahan Kalor Pada Heat Exchanger Pipa Ganda Dengan Sirip Berbentuk Delta Wing," *Jurusan Teknik Mesin, Fakultas Teknik, Universitas Negeri Semarang*, 2007.

[33] Prasetyaningtiyas and Fibriana Ika, "Re-Design Heater Heat Exchanger PT. Petrokimia Gresik Dengan Menggunakan Analisa Termodinamika Dan Perpindahan Panas," *Jurusan Teknik Mesin, Fakultas Teknik Industri, Institut Teknologi Sepuluh Nopember Surabaya*, 2012.

[34] Bizzy I and Setiadi R, "Studi Perhtiungan Alat Penukan Kalor Tipe Shell And Tube Dengan Program Heat Transfer Research Inc. (HTRI)," *Jurusan Teknik Mesin, Fakultas Teknik, Universitas Sriwijaya*, 2013.

[35] Kib Angga Royani, "Perencanaan Sistem Pemanfaatan Panas Buang Untuk Pemanas Air Pada Sistem Domestik MT.Vanda," *Juruan Teknik Sistem Perkapalan, Institut Teknologi Sepuluh Nopember Surabaya*, 2015.

[36] Muhammad Luqmanul Hakim, "Uji Performansi Gas Air Heater di PLTU Cirebon 1x660MW," *Jurusan Teknik Mesin, Fakultas Teknik, Universitas Pasundan Bandung*, 2014.

[37] Ramesh K. Shah and Dusan P Sekulic, *Fundamentals Of Heat Exchanger Design*.: John Wiley & Sons, 2003.

[38] J P Holman, *Perpindahan Kalor*. Jakarta: Penerbit Erlangga, 1997.

[39] Faris Rahmadian A, "Re-design Air Preheater Tipe Rotating Regenerative Menjadi Tipe Concentric Counterflow Pada Boiler Pembangkit Gresik," Institut

Technology Sepuluh Nopember, Surabaya, 2016.

[40] Indra Setiawan, "Mempertahankan Kinerja Alat Penukar Kalor Dengan Memodifikasi Sistem Kerja Feeder Pump," Universivitas Indonesia, Depok, 2011.

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AUTHOR BIODATA

The author was born in Blitar on 28th September 1994, as the first child of 2 siblings. The author has completed the formal education in SDN 1 Kademangan, SMPN 2 Blitar, and SMAN 1 Blitar. The author continued her study for bachelor degree in Marine Engineering Double Degree (DDME) program of Institut Teknologi Sepuluh Nopember and Hochschule Wismar, with student id number: 4213101001 and took area of expertise in Marine Machinery and System (MMS). During the college, the author was active in marine engineering student association (HIMASISKAL), 2014-2105 period, as cabinet 2nd secretary, in the field of *kepemanduan*. The author was a *pemandu* in department level, faculty level, and also Institute level. The author has taken several trainings such as student management skill (Pra-TD) training, management activity, and management organization. The author have done on the job training in PT. Dok Perkapalan Kodja Bahari 1 Jakarta and PT. Pertamina Shipping Jakarta.

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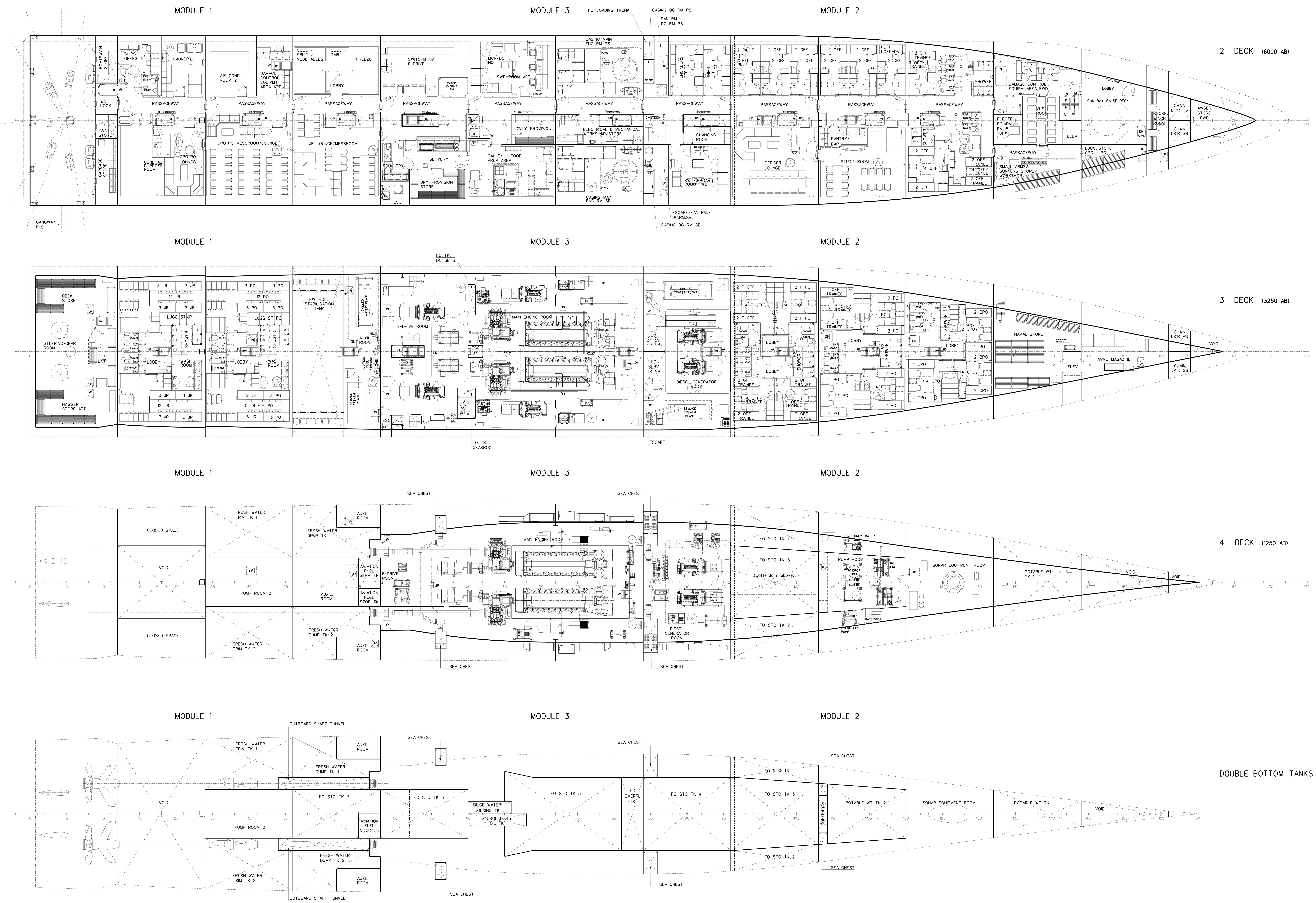
ECNLOSURE A

General Arrangement of PKR Ship

Exhasut Gas System

Domestic Water System



REV	E	DATE 19-12-2013	REVISION SUBJECT
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APPRVD	D. den Engelsman		

APPROVED		Sign	Date

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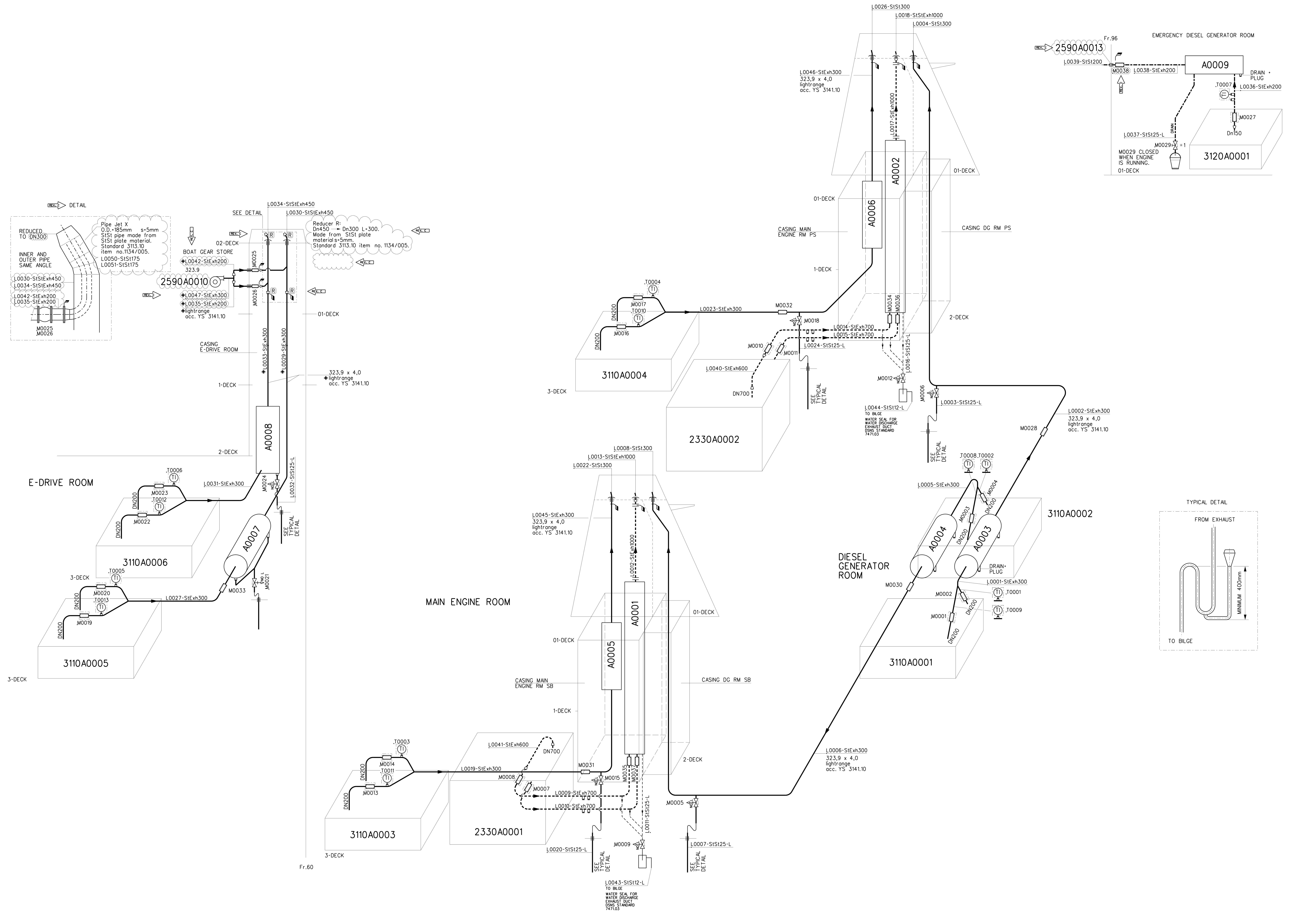
DRAWN	J. Lijnse	FORMAT	A04
CHECKED	P. Polderman	SCALE	100
APPROVED	D. den Engelsman	DATE	27-02-2013

PROJECTION

GENERAL ARRANGEMENT PLAN

PROJECT	PKR-SIGMA		DERIVED FROM DWG
COMP NO	SECT NO	YARD NO contractor	DWG NO E10500.01
		YARD NO building yard 414/415	SHEET 2 REVISION E



DN	Exhausts StExh-pipe Dia. x Th.	DN	Steel Outside diam.	Thickness N	Thickness H	Thickness EH	Stainl. St. AISI 316L L Dia. x Th.	Stainl. St. AISI 316L N Dia. x Th.		
125	139,7x6,3	4						8x1,5		
150	168,3x6,3	8	12,0	2,0	2,0			12x2,0		
200	219,1x6,3	10					12x1,5			
250	273x6,3	12	16,0	2,0	2,0		15x1,5	16x2,0		
300	323,9x6,3	15	20,0	2,0	2,0		18x1,5	20x2,0		
350	355,6x6,3	16								
400	406,4x6,3	20	25,0	2,0	3,0		22x2,0	25x3,0		
450	457x6,3	25	30,0	2,5	4,0		28x2,0	30x3,0		
500	508x6,3	32	42,4	2,6	5,0		42x3,0	42,2x2,77		
600	610x6,3	40	48,3	2,6	5,0	7,1		48,3x2,77		
700	711x6,3	50	60,3	2,9	5,0	8,8		60,3x2,77		
800	813x6,3	65	76,1	2,9	5,0	7,1		76,1x2,9		
900	914x6	80	88,9	3,2	5,0	8,0		88,9x3,05		
1000	1016x6	100	114,3	3,6	5,0	8,8		114,3x3,05		
1200	1219x6	125	139,7	4,0	5,6	8,8		139,7x4,0		
DN	StStExh	150	168,3	4,5	4,5	11,0		168,3x3,4		
		200	219,1	6,3	6,3	12,5		219,1x3,76		
	Dia. x Th.	250	273,0	6,3	6,3	12,5		273,1x4,19		
450	457x5	300	323,9	7,1	7,1	12,5		323,9x4,57		
1000	1016x5	350	355,6	8,0	8,0	12,5		355,6x4,77		
		400	406,4	8,8	8,8	12,5		406,4x4,77		
		450								
		500	508,0			12,5				

SYSTEM/SUBSYSTEM	DT °C	SYSTEM PRESSURE NP (BARG)	DP (BARG)	TPW (BARG)	TPB (BARG)
EXH GAS SYSTEM ME	444	6	1	-	-
EXH GAS SYSTEM DG SETS	390	6	1	-	-
EXH GAS SYSTEM EM DG	354	10	1	-	-

SYSTEM PART	DESCRIPTION	TYPE	CAP.	PRESS. BAR	REQ. NPSH m	REMARKS
A0001	EXH GAS SIL MAIN ENG 1 SB					
A0002	EXH GAS SIL MAIN ENG 2 PS					
A0003	EXH GAS SIL DG1 DGR SB					
A0004	EXH GAS SIL DG2 DGR PS					
A0005	EXH GAS SIL DG3 MER SB					
A0006	EXH GAS SIL DG4 MER PS					
A0007	EXH GAS SIL DG5 EDR SB					
A0008	EXH GAS SIL DG6 EDR PS					
A0009	EXH GAS SIL EM DG					
2330A0001	MAIN DIESEL ENGINE SB					
2330A0002	MAIN DIESEL ENGINE PS					
2590A0010	JETxBOX FAN ME-04 E-DR DG-EXHSTS					
2590A0013	HEAT REDUCTION PENETR. EDG EXHST					
3110A0001	DIESEL GENERATOR 1 DGR SB					
3110A0002	DIESEL GENERATOR 2 DGR PS					
3110A0003	DIESEL GENERATOR 3 MER SB					
3110A0004	DIESEL GENERATOR 4 MER PS					
3110A0005	DIESEL GENERATOR 5 EDR SB					
3110A0006	DIESEL GENERATOR 6 EDR PS					
3120A0001	EMERGENCY DIESEL GENERATOR					

REFERENCE/DRAWINGS

L1-GSt250-EH-II
line number
material
pipe class (only class I and II annotated)
wall thickness (only H and EH annotated)
nominal diameter

Abbreviations explanation:

St = Steel	StSt = Stainless Steel	IfitPE = I-fit PE Multilayer
GSt = Galvanized Steel	Cn = CuNi10Fe	PB = Poly Butylene
Ki = KIWA	Cun = CuNi30Fe	PPFR = Poly Propylene (Fuseal Seadrain)
StHull = Steel Hull connection pipe	PE = Poly Ethylene	

NOTES

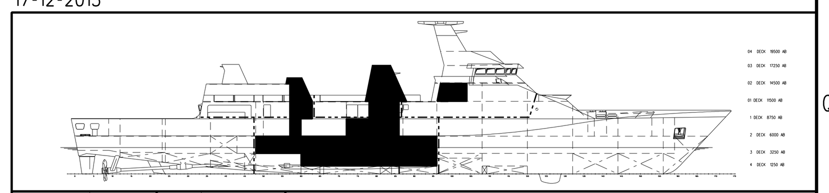
EXHAUST SYSTEM MAIN ENGINES
EXHAUST SYSTEM DG SETS
EXHAUST SYSTEM EM DG
NIPPLE WITH PLUG 1/2" FOR LOCAL MEASURE CONNECTION (TEMPERATURE AND/OR PRESSURE)

-Pipe below drainvalve provided with hook for bucket. (Dwg 8420.01)
-Position: to be easily reached.

Delivered by Sub Contractor.

TI Delivered by Sub Contractor.

17-12-2013



REV	C	DATE 29-12-2013	REVISION SUBJECT
DRWN	J. de Kam		ADD: L0050, L0051, M0038
CHCKD	R. Rottier		MOD: L0035, L0042, L0047
APPRVD	D. den Engelsman		OBSOLETE: L0048, L0049

APPROVED	Sign	Date
LRS		
TNI-AL		

DAMEN
DAMEN SCHELDE NAVAL SHIPBUILDING
P.O. Box 555 4380 AN Vlissingen The Netherlands

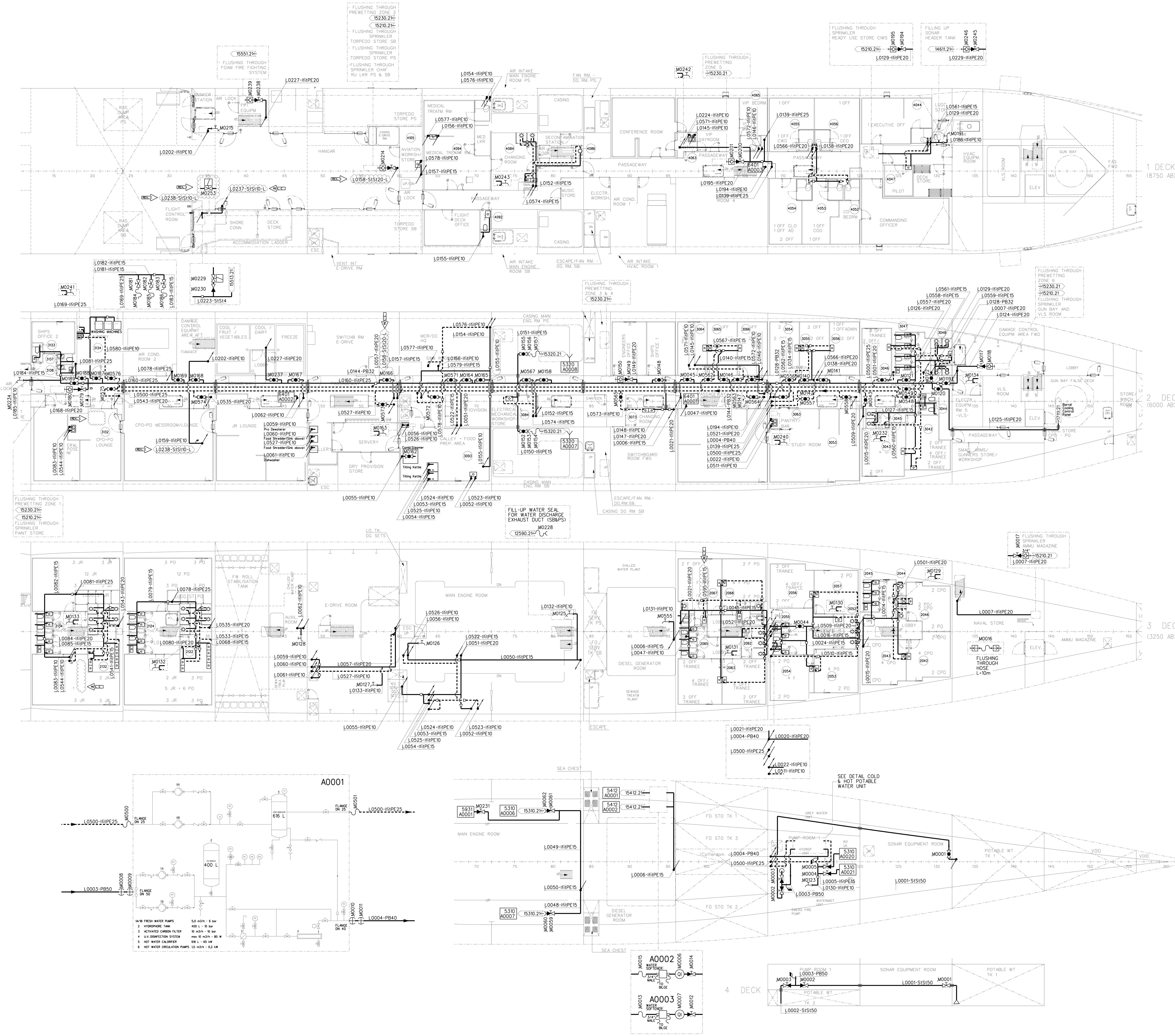
ΣIGMA
10514

DRAWN	J. de Kam	FORMAT	A0
CHECKED	R. Rottier	SCALE	100
APPROVED	D. den Engelsman	DATE	26-06-2013

PROJECTION

DIAGRAM EXHAUST GAS SYSTEM

PROJECT	PKR-SIGMA	DERIVED FROM DWG		
COMP NO	SECT NO	YARD NO contractor / YARD NO building yard 414/415	DWG NO E12590.21	SHEET 1 / REVISION C



3 DECK

SPACE NR	LINE NR	TOILET BOWL	URINAL	WASHING BASIN	SANITARY UNIT	SHOWER	BALL VALVE
2042	L0008-IfitPE10			■			M0018
2042	L0505-IfitPE10			■			M0502
2043	L0008-IfitPE10			■			M0019
2043	L0505-IfitPE10			■			M0503
2044	L0009-IfitPE10					■	M0020
2044	L0504-IfitPE10					■	M0504
2044	L0012-IfitPE10					■	M0021
2044	L0502-IfitPE10					■	M0505
2044	L0010-IfitPE10			■			M0022
2044	L0503-IfitPE10			■			M0506
2045	L0013-IfitPE10	■					M0023
2045	L0013-IfitPE10			■			M0024
2045	L0013-IfitPE10	■					M0025
2045	L0013-IfitPE10			■			M0026
2045	L0013-IfitPE10	■					M0027
2045	L0013-IfitPE10			■			M0028
2046	L0010-IfitPE10			■			M0029
2046	L0504-IfitPE10			■			M0507
2052	L0017-IfitPE10					■	M0030
2052	L0506-IfitPE10					■	M0508
2052	L0018-IfitPE10					■	M0031
2052	L0507-IfitPE10					■	M0509
2052	L0019-IfitPE10					■	M0032
2052	L0508-IfitPE10					■	M0510
2052	L0225-IfitPE10			■			M0235
2052	L0592-IfitPE10			■			M0596
2053	L0230-IfitPE10			■			M0033
2053	L0594-IfitPE10			■			M0511
2054	L0230-IfitPE10			■			M0034
2054	L0594-IfitPE10			■			M0512
2055	L0025-IfitPE10	■					M0035
2055	L0026-IfitPE10			■			M0036
2055	L0027-IfitPE10	■					M0037
2055	L0028-IfitPE10			■			M0038
2055	L0029-IfitPE10		■				M0039
2055	L0030-IfitPE10			■			M0040
2056	L0031-IfitPE10			■			M0041
2056	L0513-IfitPE10			■			M0513
2057	L0031-IfitPE10			■			M0042
2057	L0513-IfitPE10			■			M0514
2062	L0032-IfitPE10					■	M0046
2062	L0514-IfitPE10					■	M0516
2062	L0033-IfitPE10					■	M0047
2062	L0515-IfitPE10					■	M0517
2062	L0034-IfitPE10					■	M0048
2062	L0516-IfitPE10					■	M0518
2062	L0226-IfitPE10			■			M0236
2062	L0593-IfitPE10			■			M0597
2062	L0231-IfitPE10	■					M0247
2062	L0232-IfitPE10					■	M0248
2062	L0596-IfitPE10					■	M0598
2062	L0233-IfitPE10			■			M0249
2062	L0597-IfitPE10			■			M0599
2063	L0035-IfitPE10			■			M0049
2063	L0517-IfitPE10			■			M0519
2064	L0036-IfitPE10			■			M0050
2064	L0518-IfitPE10			■			M0520
2065	L0037-IfitPE10	■					M0051
2065	L0038-IfitPE10			■			M0052
2065	L0039-IfitPE10	■					M0053
2065	L0040-IfitPE10			■			M0054
2065	L0041-IfitPE10	■					M0055
2065	L0042-IfitPE10			■			M0056
2065	L0234-IfitPE10	■					M0250
2065	L0235-IfitPE10					■	M0251
2065	L0598-IfitPE10					■	M0600
2065	L0236-IfitPE10			■			M0252
2065	L0599-IfitPE10			■			M0601
2067	L0043-IfitPE10			■			M0057
2067	L0519-IfitPE10			■			M0521
2068	L0044-IfitPE10			■			M0058
2068	L0520-IfitPE10			■			M0522
2122	L0063-IfitPE10					■	M0065
2122	L0528-IfitPE10					■	M0523
2122	L0064-IfitPE10					■	M0066
2122	L0529-IfitPE10					■	M0524
2122	L0065-IfitPE10					■	M0067
2122	L0530-IfitPE10					■	M0525
2122	L0066-IfitPE10					■	M0068
2122	L0531-IfitPE10					■	M0526
2122	L0067-IfitPE10					■	M0069
2122	L0532-IfitPE10					■	M0527
2122	L0068-IfitPE15			■			M0070
2122	L0533-IfitPE15			■			M0528
2122	L0069-IfitPE10			■			M0071
2122	L0534-IfitPE10			■			M0529
2124	L0070-IfitPE10		■				M0072
2124	L0071-IfitPE10			■			M0073
2124	L0072-IfitPE10	■					M0074
2124	L0073-IfitPE10			■			M0075
2124	L0074-IfitPE10	■					M0076
2124	L0075-IfitPE10			■			M0077
2124	L0076-IfitPE10	■					M0078
2124	L0077-IfitPE10			■			M0079
2132	L0087-IfitPE10					■	M0080
2132	L0536-IfitPE10					■	M0530
2132	L0088-IfitPE10					■	M0081
2132	L0537-IfitPE10					■	M0531
2132	L0089-IfitPE10					■	M0082
2132	L0538-IfitPE10					■	M0532
2132	L0090-IfitPE10					■	M0083
2132	L0539-IfitPE10					■	M0533
2132	L0091-IfitPE10					■	M0084
2132	L0540-IfitPE10					■	M0534
2132	L0085-IfitPE15			■			M0085
2132	L0541-IfitPE15			■			M0535
2132	L0092-IfitPE10			■			M0086
2132	L0542-IfitPE10			■			M0536
2134	L0093-IfitPE10		■				M0086
2134	L0094-IfitPE10			■			M0087
2134	L0095-IfitPE10	■					M0088
2134	L0096-IfitPE10			■			M0089
2134	L0097-IfitPE10	■					M0090
2134	L0098-IfitPE10			■			M0091
2134	L0099-IfitPE10	■					M0092
2134	L0100-IfitPE10			■			M0093

REV. C

2 DECK

SPACE NR	LINE NR	TOILET BOWL	URINAL	WASHING BASIN	SANITARY UNIT	SHOWER	BALL VALVE
3042	L0101-IfitPE10			■			M0094
3042	L0546-IfitPE10			■			M0537
3043	L0102-IfitPE10			■			M0095
3043	L0547-IfitPE10			■			M0538
3044	L0103-IfitPE10	■					M0096
3044	L0104-IfitPE10			■			M0097
3044	L0105-IfitPE10	■					M0098
3044	L0106-IfitPE10			■			M0099
3045	L0107-IfitPE10					■	M0100
3045	L0548-IfitPE10					■	M0539
3045	L0108-IfitPE10					■	M0101
3045	L0549-IfitPE10					■	M0540
3045	L0109-IfitPE10			■			M0102
3045	L0550-IfitPE10			■			M0541
3046	L0110-IfitPE10			■			M0103
3046	L0551-IfitPE10			■			M0542
3047	L0111-IfitPE10	■					M0104
3047	L0112-IfitPE10			■			M0105
3047	L0113-IfitPE10	■					M0106
3047	L0114-IfitPE10			■			M0107
3047	L0115-IfitPE10	■					M0108
3047	L0116-IfitPE10			■			M0109
3047	L0117-IfitPE10		■				M0110
3047	L0118-IfitPE10			■			M0111
3048	L0119-IfitPE10					■	M0112
3048	L0552-IfitPE10					■	M0543
3048	L0120-IfitPE10					■	M0113
3048	L0553-IfitPE10					■	M0544
3048	L0121-IfitPE10					■	M0114
3048	L0554-IfitPE10					■	M0545
3048	L0122-IfitPE10					■	M0115
3048	L0555-IfitPE10					■	M0546
3048	L0123-IfitPE10			■			M0116
3048	L0556-IfitPE10			■			M0547
3054	L0135-IfitPE10			■			M0136
3054	L0563-IfitPE10			■			M0551
3055	L0136-IfitPE10			■			M0137
3055	L0564-IfitPE10			■			M0552
3056	L0137-IfitPE10			■			M0138
3056	L0565-IfitPE10			■			M0553
3063	L0022-IfitPE10			■			M0139
3063	L0511-IfitPE10			■			M0554
3064	L0141-IfitPE10			■			M0143
3064	L0568-IfitPE10			■			M0559
3065	L0142-IfitPE10			■			M0144
3065	L0569-IfitPE10			■			M0560
3066	L0143-IfitPE10			■			M0145
3066	L0570-IfitPE10			■			M0561
3073	L0148-IfitPE10			■			M0151
3073	L0573-IfitPE10			■			M0566
3084	L0153-IfitPE10			■			M0159
3084	L0575-IfitPE10			■			M0568
3093	L0052-IfitPE10			■			M0160
3093	L0523-IfitPE10			■			M0569
3093	L0056-IfitPE10			■			M0161
3093	L0526-IfitPE10			■			M0570
3132	L0083-IfitPE10			■			M0170
3132	L0544-IfitPE10			■			M0577
3133	L0161-IfitPE10	■					M0172
3133	L0162-IfitPE10			■			M0173
3134	L0163-IfitPE10			■			M0174
3134	L0580-IfitPE10			■			M0579
3137	L0164-IfitPE10	■					M0175
3137	L0165-IfitPE10			■			M0176
3138	L0166-IfitPE10		■				M0177
3138	L0167-IfitPE10			■			M0178

1 DECK

SPACE NR	LINE NR	TOILET BOWL	URINAL	WASHING BASIN	SANITARY UNIT	SHOWER	BALL VALVE
4044	L0187-IfitPE10				■		M0192
4044	L0581-IfitPE10				■		M0580
4047	L0188-IfitPE10			■			M0193
4047	L0582-IfitPE10			■			M0581
4052	L0189-IfitPE10				■		M0196
4052	L0583-IfitPE10				■		M0582
4053	L0190-IfitPE10				■		M0197
4053	L0584-IfitPE10				■		M0583
4054	L0191-IfitPE10				■		M0196
4054	L0585-IfitPE10				■		M0584
4055	L0192-IfitPE10				■		M0198
4055	L0586-IfitPE10				■		M0585
4056	L0193-IfitPE10				■		M0199
4056	L0587-IfitPE10				■		M0586
4063	L0145-IfitPE10			■			M0202
4063	L0571-IfitPE10			■			M0587
4065	L0146-IfitPE10				■		M0203
4065	L0572-IfitPE10				■		M0588
4084	L0196-IfitPE10					■	M0204
4084	L0588-IfitPE10					■	M0589
4084	L0197-IfitPE10					■	M0205
4084	L0589-IfitPE10					■	M0590
4084	L0198-IfitPE10			■			M0206
4084	L0590-IfitPE10			■			M0591
4086	L0199-IfitPE10					■	M0207
4086	L0591-IfitPE10					■	M0592
4092	L0200-IfitPE10	■					M0208
4092	L0201-IfitPE10			■			M0209
4094	L0154-IfitPE10				■		M0210
4094	L0576-IfitPE10				■		M0593
4094	L0156-IfitPE10			■			M0211
4094	L0577-IfitPE10			■			M0594
4105	L0207-IfitPE10			■			M0212
4105	L0578-IfitPE10			■			M0595

DN	Steel Outside diam.	Steel Thickness N	Steel Thickness H	Steel Thickness EH	IfitPE Dia. x Th.	PB Instaflex Dia. x Th.	Stainl. St. AISI 316L L Dia. x Th.	
4								
8	12,0	2,0	2,0					
10					16x2,0	16x2,2	12x1,5	
12	16,0	2,0	2,0				15x1,5	
15	20,0	2,0	2,0		20x2,0	20x2,8	18x1,5	
16								
20	25,0	2,0	3,0		25x2,5	25x2,3	22x2,0	
25	30,0	2,5	4,0		32x3,0	32x2,9	28x2,0	
32	42,4	2,6	5,0			40x3,7	42x3,0	
40	48,3	2,6	5,0	7,1		50x4,6		
50	60,3	2,9	5,0	8,8		63x5,8		
65	76,1	2,9	5,0	7,1		75x6,8		
80	88,9	3,2	5,0	8,0		90x8,2		
100	114,3	3,6	5,0	8,8		110x10,0		
125	139,7	4,0	5,6	8,8				
150	168,3	4,5	5,6	11,0		160x14,6		
200	219,1	6,3	6,3	12,5		225x20,5		
250	273,0	6,3	6,3	12,5				
300	323,9	7,1	7,1	12,5				
350	355,6	8,0	8,0	12,5				
400	406,4	8,8	8,8	12,5				
450								
500	508,0			12,5				

SYSTEM/SUBSYSTEM	DT °C	SYSTEM PRESSURE NP (BARG)	DP (BARG)	TPW (BARG)	TPB (BARG)

SYSTEM PART	DESCRIPTION	TYPE	CAP.	PRESS. BAR	REQ. NPSH m	REMARKS
A0001	COLD & HOT POTABLE WATER UNIT					
A0002	WATER SOFTENER					
A0003	WATER SOFTENER					
5310A0006	FEED WATER TREATMENT UNIT PS					
5310A0007	FEED WATER TREATMENT UNIT SB					
5310A0020	REVERSE OSMOSIS UNIT PS					
5310A0021	REVERSE OSMOSIS UNIT SB					
5320A0007	COOLING WATER EXP. TK MDE SB					
5320A0008	COOLING WATER EXP. TK MDE PS					
5320A0012	COOLING WATER EXP. TK E-DRIVE					
5412A0001	FUEL OIL SEPARATOR UNIT FWD					
5412A0002	FUEL OIL SEPARATOR UNIT AFT					
5931A0001	OILY BILGE SEPARATOR					
6401A0001	DRINKWATER COOLER					
6401A0002	DRINKWATER COOLER					
6401A0003	DRINKWATER COOLER					

REFERENCE/DRAWINGS

E12590.21	DIAGRAM EXHAUST GAS SYSTEM
E14611.21	DIAGRAM WATER FILLING SONAR DOME
E15210.21	DIAGRAM HPSW FIRE MAIN SYSTEM INCL SPRINKLERS
E15230.21	DIAGRAM PREWETTING SYSTEM
E15320.21	DIAGRAM FRESHWATER COOLING SYSTEM
E15412.21	DIAGRAM FUEL OIL SERVICE SYSTEM
E15513.21	DIAGRAM WORKING AIR SYSTEM
E17111.21	DIAGRAM MAIN GUN BARREL COOLING

L1-GSt250-EH-II
line number — material — nominal diameter — wall thickness (only H and EH annotated) — pipe class (only class I and II annotated)

Abbreviations explanation:

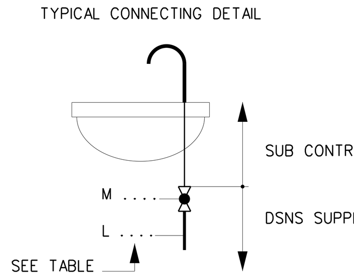
St = Steel
GSt = Galvanized Steel
Ki = KIWA
StHull = Steel Hull connection pipe
StSt = Stainless Steel
Cn = CuNi10Fe
Cun = CuNi30Fe
PE = Poly Ethylene
IfitPE = I-fit PE Multilayer
PB = Poly Butylene
PPFR = Poly Propylene (Fuseal Seadrain)

NOTES

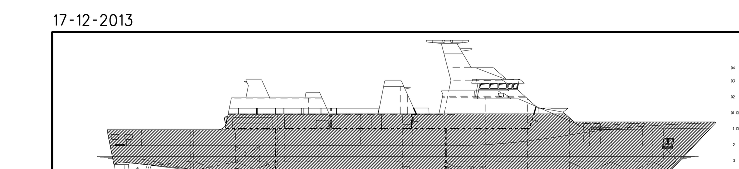
- EACH TOILET WILL BE PROVIDED WITH A SHATTAF TO BE PLACED AND CONNECTED BY ACCOMMODATION SUPPLIER.

COLD POTABLE WATER (L0001 ... L0499, M0001 ... M0499)
HOT POTABLE WATER (L0500 ... L0999, M0500 ... M0999)

TYPICAL CONNECTING DETAIL



17-12-2013



REV	C	DATE 20-12-2013	REVISION SUBJECT
DRWN	J. de Kam		ADD: L0230 u/i L0238, L0594 u/i L0599, M0247 u/i M0254
CHCKD	J. Nieuwenhuijse		M0598 u/i M0601. MOD: L0158
APPRVD	D. den Engelsman		OBSOLETE: L0046, L0086, L0545, M0171, M0190, M0578

APPROVED	Sign	Date

DAMEN

DAMEN SCHELDE NAVAL SHIPBUILDING
P.O. Box 555 4380 AN Vlissingen The Netherlands

ΣIGMA 10514

DRAWN	J. de Kam	FORMAT	A04
CHECKED	R. Rottier	SCALE	100
APPROVED	D. den Engelsman	DATE	09-07-2013

PROJECTION

DIAGRAM DOMESTIC FRESH WATER SYSTEM

COMP NO	SECT NO	PROJECT PKR-SIGMA	DERIVED FROM DWG		
		YARD NO contractor	DWG NO	SHEET	REVISION
		YARD NO building yard 414/415	E15330.21	1	C

ECNLOSURE B
Project Guide of Auxilary Engine

C32 Generator Set

Electric Power

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

Specifications

Generator Set Specifications	
Minimum Rating	830 ekW (910 kVA)
Maximum Rating	1000 ekW (1250 kVA)
Voltage	220 to 4160
Frequency	50 or 60 Hz
Speed	1500 or 1800 RPM

Generator Set Configurations	
Emissions/Fuel Strategy	Low Fuel Consumption, Low Emissions, EPA Certified for Stationary Emergency Application (Emits Equivalent U.S. EPA Tier 2 Nonroad Standards)

Engine Specifications		
Engine Model	C32 TA, V-12, 4-Stroke Water-Cooled Diesel	
Bore	145 mm	5.71 in
Displacement	32.1 L	1958.86 in^3
Stroke	162 mm	6.38 in
Compression Ratio	15.0:1	
Aspiration	TA	
Governor Type	Adem™A4	
Fuel System	MEUI	

PERFORMANCE DATA[DM9933]

February 16, 2016

Performance Number: DM9933 **Change Level: 03**

SALES MODEL:	C32	**COMBUSTION:**	DI
ENGINE POWER (BHP):	1,474	**ENGINE SPEED (RPM):**	1,800
GEN POWER WITH FAN (EKW):	1,000.0	**HERTZ:**	60
COMPRESSION RATIO:	15.0	**FAN POWER (HP):**	56.3
RATING LEVEL:	STANDBY	**ADDITIONAL PARASITICS (HP):**	1.3
PUMP QUANTITY:	1	**ASPIRATION:**	TA
FUEL TYPE:	DIESEL	**AFTERCOOLER TYPE:**	ATAAC
MANIFOLD TYPE:	DRY	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
GOVERNOR TYPE:	ADEM4	**INLET MANIFOLD AIR TEMP (F):**	120
ELECTRONICS TYPE:	ADEM4	**JACKET WATER TEMP (F):**	210.2
IGNITION TYPE:	CI	**TURBO CONFIGURATION:**	PARALLEL
INJECTOR TYPE:	EUI	**TURBO QUANTITY:**	2
REF EXH STACK DIAMETER (IN):	8	**TURBOCHARGER MODEL:**	GTB45518BS-52T-1.37
MAX OPERATING ALTITUDE (FT):	997	**CERTIFICATION YEAR:**	2007
		PISTON SPD @ RATED ENG SPD (FT/MIN):	1,913.4

INDUSTRY	SUBINDUSTRY	APPLICATION
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
1,000.0	100	1,474	331	0.342	71.9	70.3	118.2	1,209.3	58.1	889.5
900.0	90	1,330	299	0.341	64.7	64.0	111.0	1,150.9	51.9	855.4
800.0	80	1,187	267	0.349	59.2	60.4	106.5	1,116.3	48.6	832.2
750.0	75	1,116	251	0.354	56.4	57.9	103.8	1,100.0	46.6	821.0
700.0	70	1,046	235	0.354	52.9	53.7	99.5	1,077.6	43.2	810.0
600.0	60	905	203	0.353	45.7	43.7	90.1	1,025.8	35.3	788.8
500.0	50	765	172	0.350	38.2	32.9	80.8	964.8	27.0	768.5
400.0	40	628	141	0.351	31.5	23.9	74.7	895.9	20.5	731.2
300.0	30	490	110	0.357	25.0	15.7	70.4	812.1	15.1	676.7
250.0	25	420	94	0.363	21.8	12.0	68.9	764.0	12.7	643.0
200.0	20	350	79	0.374	18.7	8.7	67.9	708.9	10.6	601.8
100.0	10	206	46	0.425	12.5	4.5	67.5	569.8	7.8	489.0

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
1,000.0	100	1,474	76	422.1	3,094.1	8,065.3	13,465.4	13,968.9	2,939.2	2,688.4
900.0	90	1,330	69	391.5	2,939.0	7,417.0	12,749.0	13,202.3	2,773.0	2,544.8
800.0	80	1,187	65	375.1	2,856.2	7,051.1	12,358.8	12,773.3	2,683.6	2,472.3
750.0	75	1,116	63	363.9	2,783.7	6,813.1	12,021.7	12,415.6	2,615.7	2,413.9
700.0	70	1,046	58	343.3	2,639.5	6,395.9	11,355.9	11,723.5	2,476.8	2,288.3
600.0	60	905	48	302.6	2,355.5	5,576.9	10,061.2	10,377.6	2,196.4	2,033.1
500.0	50	765	37	262.3	2,076.5	4,775.6	8,810.4	9,077.6	1,911.9	1,773.0
400.0	40	628	27	223.0	1,805.8	4,001.6	7,595.0	7,814.6	1,652.1	1,535.9
300.0	30	490	18	183.7	1,537.6	3,237.7	6,435.6	6,610.0	1,400.8	1,306.8
250.0	25	420	14	163.9	1,403.3	2,856.8	5,874.1	6,026.7	1,273.8	1,190.9
200.0	20	350	11	146.2	1,286.2	2,507.0	5,386.7	5,517.7	1,161.2	1,089.1
100.0	10	206	6	122.6	1,147.6	1,981.6	4,797.2	4,885.1	1,027.0	974.3

ECNLOSURE C
Equipment selection

Temperature Indicator

View larger image

Overview

Specifications

Place of Origin:	Shaanxi, China (Mainland)	Brand Name:	GAIMC	Model Number:	GTC701
Usage:	Industrial	Theory:	Alarm temperature indicator	Accuracy:	0.3
Temperature r...	According to input	Input signal:	Thermocouple, RTD, liner volt...	Alarm:	Four programmable alarms
Panel size:	96*96, 160*80, 80*160, 72*72...	Auxiliary input:	Direct current	Auxiliary alarm:	Relay
Communication:	RS485	Display:	LED	Output:	Liner current
Housing color:	Black / gray	Item:	GTC701 Digital thermocouple...		

Packaging & Delivery

Packaging Details:	Standard export packaging
Delivery Detail:	Shipped in 10 days after payment

GTC701 Digital thermocouple alarm temperature indicator

Pressure Indicator

View larger image

Overview

Specifications

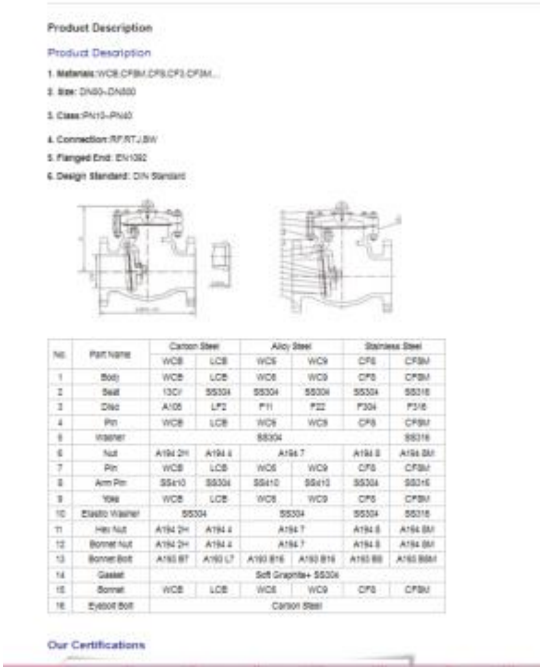
Place of Origin:	Fujian, China (Mainland)	Brand Name:	YUDIAN	Model Number:	AI-500
Usage:	Industrial	Theory:	Temperature Controller	Accuracy:	0.3%FS±1°C
Temperature r...	0~9999	Input Type:	Thermocouple: K, S, R, E, J, N;...	Operating Am...	-10℃ to 60℃ ; ≤90%RH
Power supply:	100-240VAC/ 50-60Hz; 24VD...	Temperature D...	0.1 or 1	Alarm Function:	High limit, Lower limit, secon...
Power Supply ...	100-240VAC, -15%, +10% / 50-...	Power Consu...	≤5W	Temperature S...	≤0.015%FS/℃
Color:	Grey or Black	Name:	AI-500 Pressure Indicator Su...		

Packaging & Delivery

Packaging Details: Standard Carton boxes with Yudian logo for AI-500 Pressure Indicator Supplier Digital Temperature Indicator

Delivery Detail: Shipped in 2 days after payment

Non Return Valve



Product Description

Product Description

1. **Materials**:WCB,CF8M,CF8,CF3,CF3M...
2. **Size**: DN50~DN500
3. **Class**:PN10~PN40
4. **Connection**:RF,RTJ,BW
5. **Flanged End**: EN1092
6. **Design Standard**: DIN Standard

No.	Part Name	Carbon Steel		Alloy Steel		Stainless Steel	
		WCB	LCB	WC6	WC9	CF8	CF8M
1	Body	WCB	LCB	WC6	WC9	CF8	CF8M
2	Seat	13Cr	SS304	SS304	SS304	SS304	SS316
3	Disc	A105	LF2	F11	F22	F304	F316
4	Pin	WCB	LCB	WC6	WC9	CF8	CF8M
5	Washer	SS304					SS316
6	Nut	A194 2H	A194 4	A194 7		A194 8	A194 8M
7	Pin	WCB	LCB	WC6	WC9	CF8	CF8M
8	Arm Pin	SS410	SS304	SS410	SS410	SS304	SS316
9	Yoke	WCB	LCB	WC6	WC9	CF8	CF8M
10	Elastic Washer	SS304		SS304		SS304	SS316
11	Hex Nut	A194 2H	A194 4	A194 7		A194 8	A194 8M
12	Bonnet Nut	A194 2H	A194 4	A194 7		A194 8	A194 8M
13	Bonnet Bolt	A193 B7	A193 L7	A193 B16	A193 B16	A193 B8	A193 B8M
14	Gasket	Soft Graphite+ SS304					
15	Bonnet	WCB	LCB	WC6	WC9	CF8	CF8M
16	Eyebolt Bolt	Carbon Steel					

Our Certifications

Basic Info

Model NO.: H44

Connection Form: Flange

Pressure: Ordinary Pressure

Sealing Form: Gland Packings Globe Valve

Standard: DIN

Class: Pn10~Pn40

Media: Wog

Color: as Customers Request

Power: Manual

Trademark: Lonz/OEM

Specification: DN50~DN500

HS Code: 8481300000

Material: Cast Steel

Structure: Swing

Function: Ddcv Double Lobe, Nrvr Silence, Sfcv Rubber Lobe, Nrvz Silence, Nrvg Silence

Flow Direction: Unidirection

Application: Industrial Usage, Water Industrial Usage

Certificate: API

Painting: Epoxy Painting

Fields: Metallurgy, Light Industrial, Electric Power...

Temperature: Normal Temperature

Transport Package: Woodencase

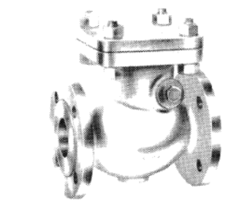
Origin: China

METRIC CAST STEEL CHECK VALVES

FLANGED ENDS

DIN or JIS SPECIFICATIONS

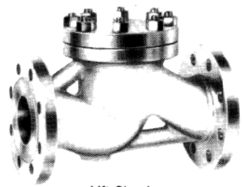
SIZES: 40mm to 500mm



DIN
PN 16 Swing Check 953501
PN 40 Lift Check 953601

PN 16 DIN (European) SWING CHECK

SIZE	40	50	65	80	100	125	150	200	250
FF	180	200	240	260	300	350	400	500	600
D	150	165	185	200	250	220	285	340	405
BC	110	125	145	160	180	210	240	295	355
wt(kg)	12	16	22	29	41	57	75	120	195



Lift Check

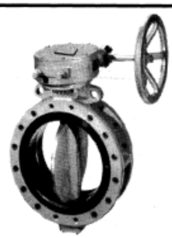
PN 40 DIN (European) LIFT CHECK

SIZE	15	20	25	32	40	50	65	80	100	125	150	200	250	300
FF	130	150	160	180	200	230	290	310	350	400	480	500	730	850
D	95	105	115	140	150	165	185	200	235	270	300	375	450	515
BC	65	75	85	100	110	125	145	160	190	220	250	320	385	450
wt(kg)	4	4	5	8	11	15	25	26	42	56	82	152	230	290

METRIC BUTTERFLY VALVES

SIZES: 40mm to 750mm
JIS and DIN

Wafer, Lug, Flanged styles in Iron, Ductile (Nodular) Iron Body, Rubber Seat. Refer to numbers and options below. Standard valve is wafer iron body, buna liner, lever.



		Wafer	Lug	Flanged
5K JIS	Brz Disc	949102-5	949202-5	949302-5
	SS Disc	949107-5	949207-5	949307-5
[illegible] JIS	Brz Disc	949102-10	949202-10	949302-10
	SS Disc	949107-10	949207-10	949307-10
PN 6 DIN	Brz Disc	949402-6	949502-6	949602-6
	SS Disc	949407-6	949507-6	949607-6
PN 10 DIN	Brz Disc	949402-10	949502-10	949602-10
	SS Disc	949407-10	949507-10	949607-10
PN 16 DIN	Brz Disc	949402-16	949502-16	949602-16
	SS Disc	949407-16	949507-16	949607-16

Options available:	Ductile (Nodular) Iron body:	add DI to item number
	Monel Disc	add MD to item number
	Gear Operator	add GO to item number
	Viton Seat/Liner	add VS to item number
	EPDM Seat/Liner	add EP to item number

Glasswool

SPESIFIKASI UNTUK KACA WOL PIPA			
Item	Unit	indeks	diukur nilai
Bulk density	kg/m3	64-160	64-160
diameter rata-rata serat	m	< 8	0 4.0-6.0
resistivitas kelembaban	%	> 98	> 98.5
konduktivitas termal	W/m	0.049-0.042	0.045-0.032
tahan api		tahan api	hingga standar (Grade A)
koefisien penyerapan suara			1.03 gema positioning produk 24 kg/m3 2000 HZ
Max. suhu kerja		400	410

Aluminium Foil

Property	Value/Comment
Specific gravity	2.7
Weight	At 6.35 µm foil weighs 17.2 g/m^2
Melting point	660°C
Electrical conductivity	37.67 m/mm^{2}d (64.94% IACS)
Electrical resistivity	2.65 µΩ.cm
Thermal conductivity	235 W/m.K
Thickness	Foil is defined as metal measuring 0.2mm (or 200 µm and below)
Surface finish	Above 40µm aluminium foil has a brightly polished surface on both sides imparted by the rolling cylinders. Below 40µm one side has a matt finish due to the process of rolling two layers of foil simultaneously. If specified by the customer, foil can be supplied below 40µm thickness with both surfaces bright. Other surface finishes such as etched, grained or embossed can be supplied to meet particular customer needs.

Level Alarm

<< Previous in Tanks, Vessels

Price: Starting at $179.00 Call For Lead Time

Manufacturer: Gizmo
Manufacturer Part No: THL/TLL

Select Product Options And Calculate Price

Configuration: Select Configuration

Working Depth: Select Working Depth

Power Supply: Select Power Supply

Material: Select Material

Quantity: 1 Add to Cart

Share

Email this page to a friend

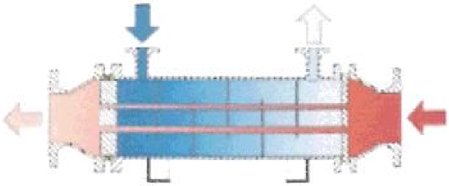
Control Valve

Technical data	
Approvals:	
Area classification (ATEX/IEC)	
2200 series:	Ex II 2G
	Exd IIB +H2
	Ex tD A21 IP6X
2600 series:	Ex II 2G
	Exd IIC
	Ex tD A21 IP6X
Enclosure standards (IEC)	
All enclosures:	IP66/67
Switches	
All Models	V3 mechanical SPDT contacts
All Models	DPDT mechanical
All Models	V3 slotted and barrel inductive proximity sensors
All Models	Magnum SPDT (hermetically sealed proximity type) switches
2200 Series	GO hermetically sealed switches, SPDT
Enclosures	
All Models	Aluminium
	Stainless steel
Falcon Solenoid Valves	
Cv:	Choice of 1.1, 3.5
Materials	Aluminium and stainless steel

Sentrifugal Pump

Merk	: EBARA
Type	: 65 DLA
Cap.	: 300 Ltr/ Mnt
Head	: 10 M
Power	: 1,5 KW/ 3 Phase/ 380 V/ 50 HZ
Price	: Rp 14.800.000,-/ Unit C/W Motor

Gas cooler, tube bundle removable
Model series A 100 (e.g. TEMA Type BEW; AEW)



Technical Description
The FUNKE heat exchanger type A 100 was designed in accordance with type CP and is exclusively available as a gas cooler - media routing "gas through the tubes" – in a tube side single-pass version. It is a heat exchanger with straight internal tubes and a removable tube bundle whose fixed tubesheet is clamped in between the shell side and tube side device flanges by means of two flat seals and bolts. The movable tubesheet, floating due to the combination of two sealing rings and a leakage ring between the device flanges, protects against a mixing of the shell side and tube side flowing media. In the case of leakages due to a single or both selaing rings being defective the pertinent media always escape towards the outside through signal bores on the circumference of the leakage ring. All seals of this design seal against atmosphere.

The tube/tubesheet connections are produced by appropriates tube expand rollings or tube weldings in accordance with the construction regulations, material combinations and operating media as well as the maximum permissible operating parameters (P/T). Naturally, to avoid gap corrosion, after a tube welding the internal tubes are roll expanded again.

The connection chambers are available in various different versions whose selection is effected in accordance with the required standards and in accordance with fluid engineering aspects.

Venting and draining points as well as a corresponding base construction are designed in relation to the installation position.

Material selection
In accordance with the respective regulations, construction regulations and operating media, carbon steels, stainless steels as well as nonferrous heavy metals are used. A reasonable integration of special materials, platings and coatings is possible.

Application
This heat exchanger type A 100 is exclusively used for cooling and drying air or similar gases, with the gas flowing on the tube side and the cooling water flowing within the shell space around the internal tubes.

Any operation with gases having a low molecular weight (e.g. hydrogen) is not effective due to the type of seal used on the floating tubesheet.

If partial condensation occurs, a cyclone separator for phase separation may be flanged directly to the outlet chamber, if required.

Acceptance
The FUNKE heat exchanger type A 100 can be supplied in accordance with all pertinent national and international certification bodies, regulations and construction regulations as e.g. pursuant to the Pressure Equipment Directive (PED), AD-2000, ASME-VIII, Div. I, U-Stamp, TEMA standard, CHINA-SQL. The integration of works standards or customer specifications is no problem either.

Boundary conditions
Due to its design and sealing type the maximum permissible operating conditions* are

	Shell side	Tube side
Maximum operating overpressure	41 bar	41 bar
Maximum operating temperature	250°C	250°C

* The maximum values may reduce due to regulations, works standards and construction regulations!

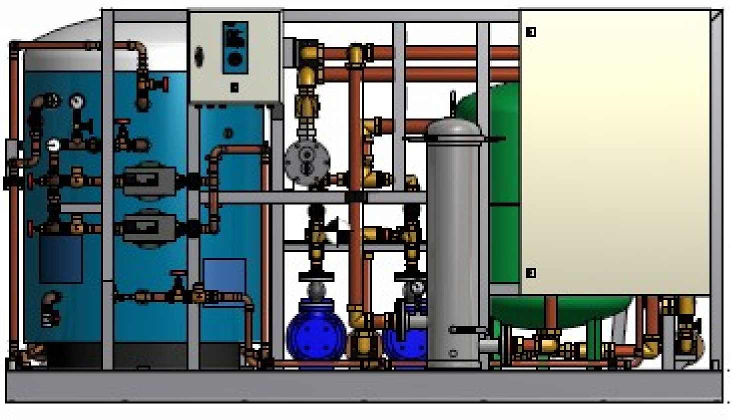
ECNLOSURE D
Hot & Cold Water System Existing

Cold & Hot potable water unit

Model: two hydrophore pumps, one hydrophore vessel, an activated carbon fine filter, an UV-disinfection system, one hot water calorifier, two hot water circulation pumps and a control box.

Operators manual & warranty

Shipment date:	March 2014
Our reference:	476032
Clients reference:	Yard no. : 414 - PKR
Address client:	Damen Schelde Naval Shipbuilding Glacisstraat 165 4381 SE Vlissingen The Netherlands



Safety instructions

This manual contains basic information that must be considered at set-up and during operation and maintenance.
For this reason, the operating, maintenance and assembly personnel must read the operating instructions before assembly, commissioning and operating.
The manual must also be available to the responsible personnel/machine minder at the place of operation at all times.
Make sure the environs of the installation is clean and well illuminated.

Qualification personnel

The operating, maintenance and assembly personnel must be appropriately qualified for the work they carry out.

Risks resulting from ignoring the safety information

Ignoring the safety information may lead to hazards for the people involved as well as endangering the environment and the system.
The non-observation of the safety information shall invalidate all claims for damages incl. compensation for damages

Maintenance

Basically the system must not be pressurized and the electrical power must be switched off before carrying out any maintenance work on the system.

Spare parts

Original spare-parts shall be used for safety-related reasons.
The use of other parts shall lead to invalidation of the warranty for any consequences resulting including claims for compensation of damages.

INDEX

1 General description

The hydrophore unit is designed to operate as a stand-alone unit.
The pumps will boost the water from the fresh water tanks to the user tap points and the hot water calorifier.
The two pumps will starts automatically by pressure switches, the hydrophore vessel is installed to prevent frequent switching of the pumps.
The selection of the sequence of the pumps is automatically switched when both pumps are switched off.
The hydrophore pumps can be switched on continuously by putting the selection switch in manual position.

Activated Carbon Water Fine Filters for the effective removal of solids and organics to improve the taste, colour and appearance of the fresh water. Housing is made of stainless steel and contains 'quick-change' elements with a selectivity of 5 microns.

The UV disinfection system emits Ultraviolet light in the UV-C band to the water flowing through the UV chamber and so disinfecting the water.
The UV unit has a control unit which shows the status of the system; power on, lamp failure and a hour-counter showing the number of hours of use.

The heating of the calorifier is electric, the three heating centres can be switched on individual.
Three heating centres of 65kW total are provided to have sufficient hot water heating capacity.
Each electrical heating element has an adjustable thermostat between 65-90 degrees C and a safety cut-off if the thermostat fails; it cuts off the current at 112 degrees C.
Do not switch on power until the calorifier is filled with clean water without chlorine.

Two hot water circulation pumps are installed, with the selection switch one pump can be set into operation and the other pump is standby, the sequence is manual by the selection switch.

2 Technical specification

<u>Hydrophore pumps</u>		
Quantity	:	2 pcs
Type	:	SK 3203LA
Make	:	Speck
Capacity	:	5 m3/ h at 6 bar.
E-motor	:	3.4kW , 3x440V/60Hz
Material	:	bronze casing, bronze impeller
<u>Fresh Water Hydrophore Vessel</u>		
Quantity	:	1 pc
Make	:	Reflex
Capacity	:	400 Ltr.
Max. working pressure	:	10 bar
Material	:	Coated carbon steel
Certification	:	PED
<u>Activated Carbon Water Fine Filter</u>		
Quantity	:	1 pc
Type	:	HDCF 7-30
Capacity	:	10 m3/ h
Max. working pressure	:	10 bar
Selectivity	:	5 microns
Material	:	Stainless Steel 1.4521
Number of cartridges	:	21pcs/each
Type of cartridges	:	HAC24870
<u>UV Water Disinfection System</u>		
Quantity	:	1 pcs
Model	:	BM175L2
Make	:	Hatenboer-Water
Capacity	:	10 m3/h
Max. working pressure	:	10 bar
Material UV chamber	:	Stainless Steel 1.4521
Power supply	:	230V/60Hz, 150Watt
<u>Hot water calorifier</u>		
Quantity	:	1 pc
Make	:	OSO
Model	:	17 RE-1000cut down
Execution	:	Vertical ships execution
Volume	:	616 ltr.
Heating	:	Electric 65kW
Electrical supply	:	3x440V/60Hz
Working pressure	:	10 bar max.
Inner tank	:	Stainless steel
Outside dimensions	:	Ø1000 mm x 1500 mm
Net Weight	:	260 kg

Hot water circulation pumps

Quantity	:	2 pcs
Make	:	WILO
Model	:	Stratos-Z 30/1-12
Capacity	:	1.5 m^3/h at 11.5 m.w.c.
E-motor	:	200W, 230V/60Hz

3 Operation

Consult parts literature before operating the installation.

Pressure control

The hydrophore vessel has two pressure switches to control the pumps.
The pressure in the system will decrease when water is consumed.
When the pressure has dropped to the switch-on value of pressure switch PS0500-01A (setting 6 – 7 bar) the first pump will start, when the pressure decrease more the second pump will be started by pressure switch PS0500-01B (setting 5 – 6 bar).
When less water is consumed, the pressure will increase until the switch-off value of the pressure switches is reached and the pumps will be switched off.
The selection of the sequence of the pumps is automatically switched when both pumps are switched off.

Low pressure alarm

The unit has a 4-20mA pressure transmitter PT 0500-01 to detect pipe-works burst, a failure of pumps, a blocked suction or other failures.

Activated carbon fine filter

As these filters are of a disposal type, regular change of the cartridge is necessary. In case of an increasing pressure drop a filter change has to be carried out.
USE ONLY CARTRIDGES SUPPLIED BY HATENBOER-WATER.
Type HAC24870; art,no. 0210- HAC24870

Read pressure indicators and compare readings with previous readings. In order to compare readings record readings. If the pressure drop is exceeding 0.8 bar over pressure drop with clean cartridges replace the filters.
In any case the cartridges should be replaced every 3 months.

The procedure to fill the cartridge filters with filter elements is:

Filling of cartridge filter

1. Make sure that the cartridge filter housing is not pressurized and the system is drained.
2. Remove the filter housing top lid by releasing the nuts on top of the filter and remove the old filter elements.
3. Place the filter elements inside the filter housing and check if the filter elements are in a straight upright position.
4. Bring the top lid back on its place and close the filter by turning the nuts.
5. Tighten the nuts crosswise and evenly.
6. De-aerate the filter housing.
7. Flush the filter before use.
8. The procedure is finished.

When the unit is in operation:
1. Check the filter housing upon leaking.
2. Remove any trapped air by opening the air-bleed valve on the top of the filter housing.

UV disinfection unit

Before putting the UV-system in operation the following precautionary measures should be taken:

- The pipe work system with the UV-system must be completely filled with liquid and de-aerated.
- The flow-rate of the liquid medium must be sufficiently high to cool the system. A flow of at least 0.1 m^3/hour is a typical value.
- Check whether the correct supply voltage is present on the connection contacts in the control cabinet.

Only switch the system on if the end closures are in position or if you are wearing safety glasses. If the end closures are not in position, a small quantity of UV-light can escape via the lamp holders. This can harm your eyes!
Never look directly into a UV-lamp that has been switched on!

- Turn the system on using the main switch. The lamps immediately start working and reach the correct output level after 1 to 5 minutes.
- Check the display to make sure all the lamps have been switched on.
- Check the output signal of the UV sensor , see section 2.8 of the manual
- Check the setting of the ECtronic printed circuit board in accordance with section 2.8. of the manual
- The UV-output indicator on the display shows the current UV-intensity.

Attention! Repeatedly switching the lamps on and off considerably shortens their life span!

Warning! If the lamps are not fully heated up, there is no guarantee of an adequate UV-dose. The flow of liquid is however required for cooling the lamps!

- If necessary, turn the system off using the main switch.

Manual cleaning system

Manual cleaning can take place while the system is operating. The required cleaning frequency depends on the medium and the UV-intensity given on the display (only where a UV-sensor is fitted).

- Remove the locking pin.

Warning! By removing the locking pin the handle of the wipe unit can be pressed forcefully to the outside by the pressure in the chamber!

- Pull the wiper system completely out with the handle or handgrip and then push it back in again. If necessary, repeat this action several times.
- Replace the locking pin.

Hot water Calorifier

The three heating centres can be switched on individual by the switches on the control panel.
Each electrical heating element has an adjustable thermostat between 65-90 degrees C and is factory adjusted.

Attention! Do not switch on power until the calorifier is filled with clean water without chlorine.

Hot water circulation

In position 1 of the selection switch circulation pump PU0600-01A is continues in operation, in position 2 pump PU0600-01B is continues in operation.

The selection of the pump in operation is manual by the selection switch.
It is advised to switch over ones a week to prevent standstill problems.

4 Installation instructions

1. Before starting any work, make sure that the HATENBOER-WATER hot and cold water unit is horizontally placed on a smooth floor. After filling the unit and vessels with water, the heavy weight of the complete machine prevents further adjustments.
2. Pipe connections must be made to and from the unit for feed water and discharge fresh water, warm water discharge and warm water circulation inlet..
3. The pipe-work must be properly supported and without stress before being connected to the unit. Refer to the Process & Instrumentation Diagram and lay-out drawing for more details. Refer to the Electrical scheme for details. The electrical scheme provides technical information on the control box. In case of an electrical failure refer to the suppliers literature and the electrical schemes.
4. The following connections have to be made by the user on the :

   MAKE SURE THAT POWER IS SHUT OFF DURING THIS PROCEDURE.

   a. Power supply (440V AC, 60 Hz, P= 73kW) to "main power switch" of the control panel .
   b. Common alarm
   c. Pump failure alarm

Attention! Do not switch on power until the calorifier is filled with clean water without chlorine.

Refer to the electrical drawings for the used coding of terminal connections.

After all connections are made, the thermal relays of the pumps have to be adjusted on the nominal current, which can be found on the nameplate of the pumps.

5 Start-up

The following procedure must be followed to start the Hydrophore unit:

Turn the pump selector switches to the "0" position.

Partly open the isolation valve's and air vent the pumps, as described in the manual of the pumps.

Completely open the isolating valves of the pumps.

Check if valves BV 0500-02, GV 0221-01 and GV0221-02 are closed.

Turn the main switch to position "1". The control voltage light will turn on.

Turn the pump control switch of pump A to "1 - automatic".

Make sure pump 1 starts and rotates in the direction indicated on the pump
Exchange two phases on the terminals if the pump rotates in the opposite direction.

Repeat this for the pump B.

The pressure switches are pre-adjusted and the unit will operate automatically, the pumps will be switch off .
If the pressure settings have to be re-adjusted see suppliers literature.

The pressure switches are pre-adjusted and the unit will operate automatically, the pumps will be switch off.
If the pressure settings have to be re-adjusted see parts literature of the switch.

Make sure the filter elements are placed in the filter housing.

Slowly open the valves GV 0221-01 and air vent the filter housing.

Slowly open the valves GV 0221-03 and GV 0430-01.
The UV chamber must be completely filled with water (no air is entrapped).
Switch on the UV disinfection units with the Main switch on the UV connection box.
Slowly open the valve GV 0430-03.

Fill up the boiler by opening the cold water inlet valve BV 0600-05. The hot water valve must remain open to let the air escape. The boiler is completely filled up when water flows out of the hot water valve.
Fill the ship hot water system and let the air flow out.
The electric heating can be switched on when the boiler and the system is completely filled with clean water without chlorine .

Put a circulation pump in operation by turning the selection switch in position 1 or 2.

Check the system upon leaking.

Shut-down

If the unit is shut-down for more then eight hours the power for the UV – steriliser must be switched off.
Note: Frequent on/off switching of the UV unit will shorten the UV lamp lifetime.

If the unit is switched off for a longer period the power for the calorifier heating elements must be switched off.

If the total unit is not operated for more then two weeks it's advised to empty the total system, to remove the filter elements and to preserve the hydrophore pumps.

Before using a system that has been switched off for a longer period, it is advised to disinfect the system with chlorine.
To disinfect the drinking water system most yards prescribes a shock chlorine concentration (a approved product such as Hadex®, can be used) High chlorine concentration can damage the heating elements. Be sure the system is rinsed effectively before starting up the calorifier. Free chlorine concentration < 2 ppm

Note : The chlorine content can be check with a chlorine test kit

During the chlorination process, the calorifier must be cold and with the power supply switched off.
Place new filter elements in the filter housings before putting the system in operation according the start-up procedure.

6 Fault diagnosis

ALWAYS disconnect power supply before opening the electric control box.

Low pressure alarm

The unit has a pressure transmitter PT0500-01 to signal pipe-works burst, a failure of pumps, a blocked suction, a closed valve or other failures.

Failure hydrophore pump

In case of a thermal shut-off the pump is stopped and an alarm is given through a red lamp on the front of the switchboard and through the general alarm-output.
The other hydrophore pump is switched on.

This alarm is caused by an overload of the pump, dry running of the pump, one phase absent , low air pressure in the hydrophore tank or wrong power supply.

A manual restart can be achieved by pressing the reset button on the thermal-block inside the switchboard, after the cause has been solved.

Failure UV unit

In case of this alarm the UV disinfection is switched off and an alarm is given through a red lamp on the front of the switchboard and through the general alarm-output.

When the "Lamp failure" LED illuminates;
Clean the quartz sleeves if the UV-intensity is too low.
Replace defective lamps (check the lamp indicators on the display), or Replace all lamps because of their age.
See the instructions in the UV-system manual.
Check the composition of the liquid and the water temperature.

Calorifier

No heating or inefficient heating.

Check the electrical power supply, the overload protection switch and the safety thermostat of the heating elements.
The reset button of the safety thermostat must be pressed to reset the safety cut off switch.

Circulation pumps

In case of a thermal shut-off the pump is stopped and an alarm is given through a red lamp on the front of the switchboard and through the general alarm-output.
The other circulation pump can be switched on with the selection switch.

This alarm is caused by an overload of the pump, dry running of the pump, one phase absent or wrong power supply.

A manual restart can be achieved by pressing the reset button on the thermal-block inside the switchboard, after the cause has been solved.

7 Recommended spare parts list

8 Drawings and Parts literature

A. Process & Instrumentation Diagram and Parts list no. 476032

B. Lay out drawing no. 476032

C. Electrical diagrams no. 476032

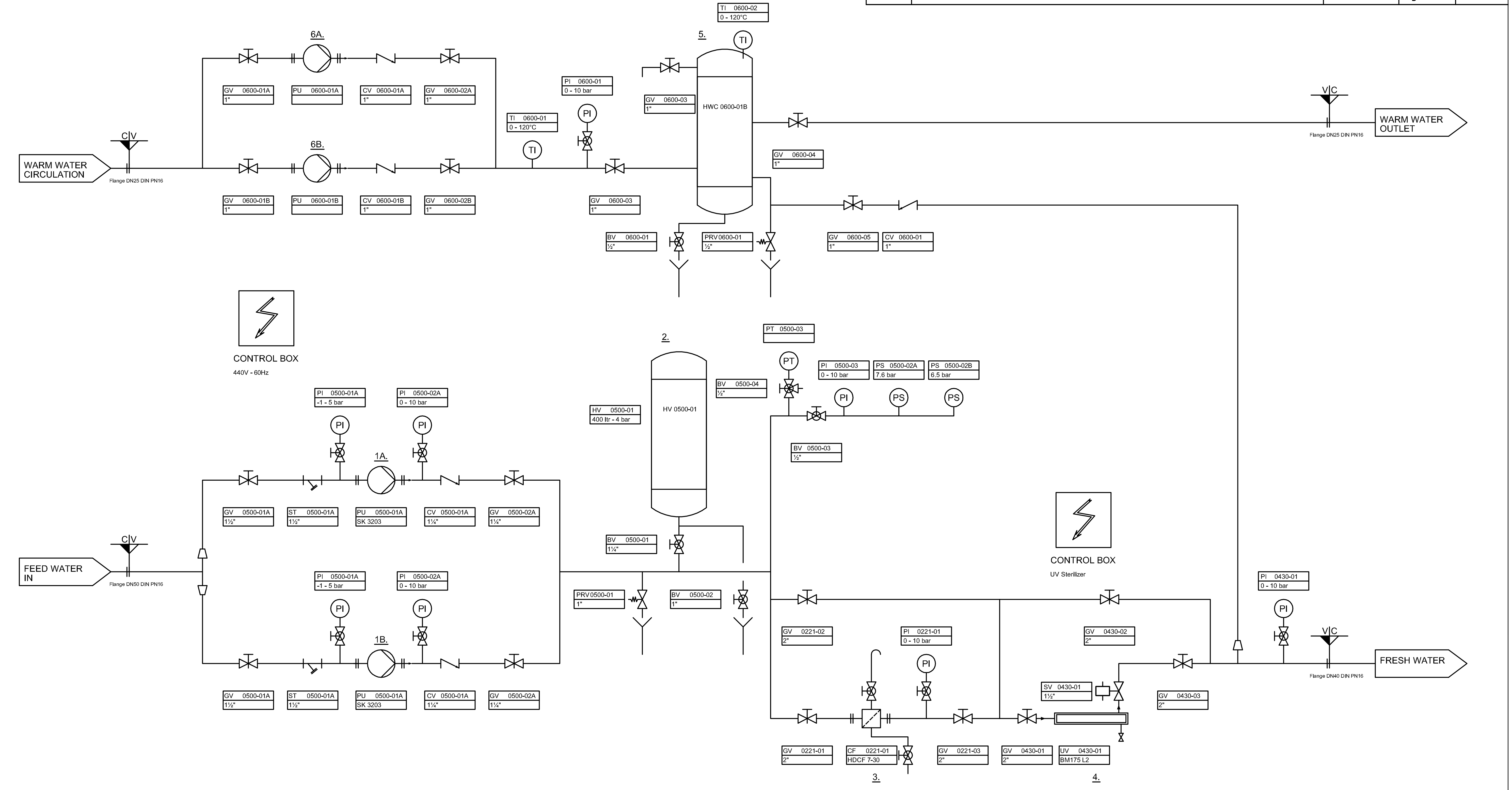
D. Hydrophore pumps	:	Speck SK 3203LA
E. Hydrophore vessel	:	Reflex DT5 0400/10
F. Pressure switch	:	Danfoss CS
G. UV-disinfection unit	:	BM175/L2
H. Hot water calorifier	:	OSO 17 RE-616/65kW
I. Circulation pumps	:	Wilo Stratos Z30/1-12
J. Filter housing	:	HDCF 7-30
K. Activated carbon fine filter	:	HAC24870
L. Pressure transmitter	:	Trafag NAT 0-10

HATENBOERWATER	Customer :	Damen Schelde Naval Schipbuilding	Revision: 0
	Customer ref. :	PO 140035/RM/I5058A	Date: 28-9-2013
		PKR	Author: P.J.
	H-W Project :	476032	
	Equipment :	Cold & Hot potable Water unit	

Spare parts & Consumables Recommendation List

Discription of Part	Model	Spare part description	Article nr.	Make	Qty for 2year	Price/pcs	Price total
Hydrophore pump	SK3203LA	Mechanical seal pos. (047) 24.13 right SK-	0426-39SK330473	Speck	2	0,00	0,00
		Impeller bronze pos. 230 SK 32/33	0426-3906230D	Speck	1	0,00	0,00
		Bearing pos. 310.1 SK-32/33	0426-39SK323101	Speck	2	0,00	0,00
		Ball bearing pos. 320 for (A)SK 32/33	0426-3906320A	Speck	2	0,00	0,00
		Gasket pos. 400 (A)SK-32/33/40	0426-39SK324000	Speck	2	0,00	0,00
		Splash ring viton 507 SK32/33	0426-39SK325070	Speck	2	0,00	0,00
		gear ring 24/28	0426-3984324280	Speck	2	0,00	0,00
		Locking ring pos. 932 (A)SK32/33	0426-390693233	Speck	2	0,00	0,00
		Key pos. 940 SK-32/33	0426-390694033	Speck	2	0,00	0,00
		Key pos. 940.1 SK-32/33	0426-390694050	Speck	2	0,00	0,00
		Tube epple liquid gasket 33	0426-390610009	Speck	2	0,00	0,00
HDCF Filter	HDCF 7-30	O-ring set	0295-HDCF07PAKKING	Hatenboer-Water	1	0,00	0,00
UV unit	BM 175 L2	UV Lamp	1041-C75	Hatenboer-Water	1	0,00	0,00
		Spares set	1041-BM175/SPARESET	Hatenboer-Water	1	0,00	0,00
		Starter	1041-STARTER/C75	Hatenboer-Water	1	0,00	0,00
Pressure indicator	-1 / 5 bar	Pressure indicator, Ø63, gly, 1/4" bottom	1902--10563OA	Hatenboer-Water	1	0,00	0,00
	0 / 10 bar	Pressure indicator, Ø63, gly, 1/4" bottom	1902-010063OA	Hatenboer-Water	1	0,00	0,00
	0/10 bar	Pressure indicator, Ø100, gly, 1/4" bottom	1902-010100OA	Hatenboer-water	1	0,00	0,00
Pressure switch	2-6 bar	Pressure switch CS2-6	1912-CS206IP5	Danfoss	1	0,00	0,00
Calorifier	17RE1000	Heating elements	1801-00073210	Hatenboer-Water	9	0,00	0,00
		Thermostats	1801-00080000	Hatenboer-Water	3	0,00	0,00
		Temperture gauge	1801-00116000	Hatenboer-Water	1	0,00	0,00
		Safety valve 1/2" Duco (replacement for SV-9	1801-000004	Hatenboer-Water	1	0,00	0,00
		Anode	1801-ANODE100	Hatenboer-Water	2	0,00	0,00
Control Cabinet	WDU2.5	Teminal WDU 2.5	0818-WDU2.5	Weidmueller	4	0,00	0,00
	WDU4	Teminal WDU 4	0818-WDU4	Weidmueller	4	0,00	0,00
	WDU6	Teminal WDU 6	0818-WDU6	Weidmueller	3	0,00	0,00
	MY4IN 24VAC	Auxiliary relay 24VAC	0806-MY4IN24	Omron	2	0,00	0,00
	PYF14S	Relay socket	0806-PYF14S	Omron	2	0,00	0,00
	M22-L-G	Signallamp IP67 green	0808-M22LG	Moeller	1	0,00	0,00
	M22-L-R	Signallamp IP67 red	0808-M22LR	Moeller	1	0,00	0,00
	M22-L-W	Signallamp IP67 white	0808-M22LW	Moeller	1	0,00	0,00
	M22-CLED-G	Led front 18-30V green	0808-M22CLEDG	Moeller	1	0,00	0,00
	M22-CLED-R	Led front 18-30V red	0808-M22CLEDR	Moeller	1	0,00	0,00
	M22-CLED-W	Led front 18-30V white	0808-M22CLEDW	Moeller	1	0,00	0,00
	M22-A	Fixing adapter	0808-M22A	Moeller	1	0,00	0,00
	S203K16	6KA circuitbreker 3P K 16A	0819-S203K16	ABB	1	0,00	0,00
	S202K6	6kA circuitbreker 2P K 6A	0819-S202K6	ABB	1	0,00	0,00
	S202K4	6kA circuitbreker 2P K 4A	0819-S202K4	ABB	1	0,00	0,00
	LC1D12B7	Contactor 24V 5,5kW 3P1NO1NC	0801-D12B7	Telemecanique	1	0,00	0,00
	LC1D09B7	Contactor 24V 4kW 3P1NO1NC	0801-D09B7	Telemecanique	1	0,00	0,00
Consumables							
UV unit	BM 175 L2	UV Lamp	1041-C75	Hatenboer-Water	1		0,00
Cartridge filter	AC Filter element	A/C HAC 248x70 5 micron	0210-HAC24870	Hatenboer-Water	84		0,00
		TOTAL AMOUNT					0,00

Prices are in Euro excl VAT
Delivery is free address Netherlands
Packing & labeling according to makers standard
Validity until ...2014



RevNo	Revision note	Date	Signature	Checked

TECHNICAL INFORMATION

POS.	QNTY	DESCRIPTION	TECHN. DATA	TECHN. DATA
1A/1B	2	FRESH WATER PUMPS	SK3203 LA	5,0m^3/h at 6 bar 3,4 kW
2	1	HYDROPHORE TANK	DT5 0400/10	400 litres, 10 bar
3	1	ACTIVATED CARBON FILTER	HDCF 7-30	10 m^3/h, 10 bar
4	1	U.V. DISINFECTION SYSTEM	BM175 L2	max. 10 m^3/h, 80W
5	1	HOT WATER CALORIFIER	17RE-1000	616 litres, 65 kW
6A/6B	2	HOT WATER CIRCULATION PUMPS	STRATOS-Z 30/1-12	1,5 m^3/h, 0,2 kW

PROJECT INFORMATION:
Project: 476032
Damen Schelde Naval Shipbuilding
YN 414-PKR
Cold and Hot Water Unit 91-130 POB

HATENBOERWATER

DRAWING INFORMATION:
P&ID

0	First issue	26-04-13	AK
Rev:	Modification:	Date:	App:

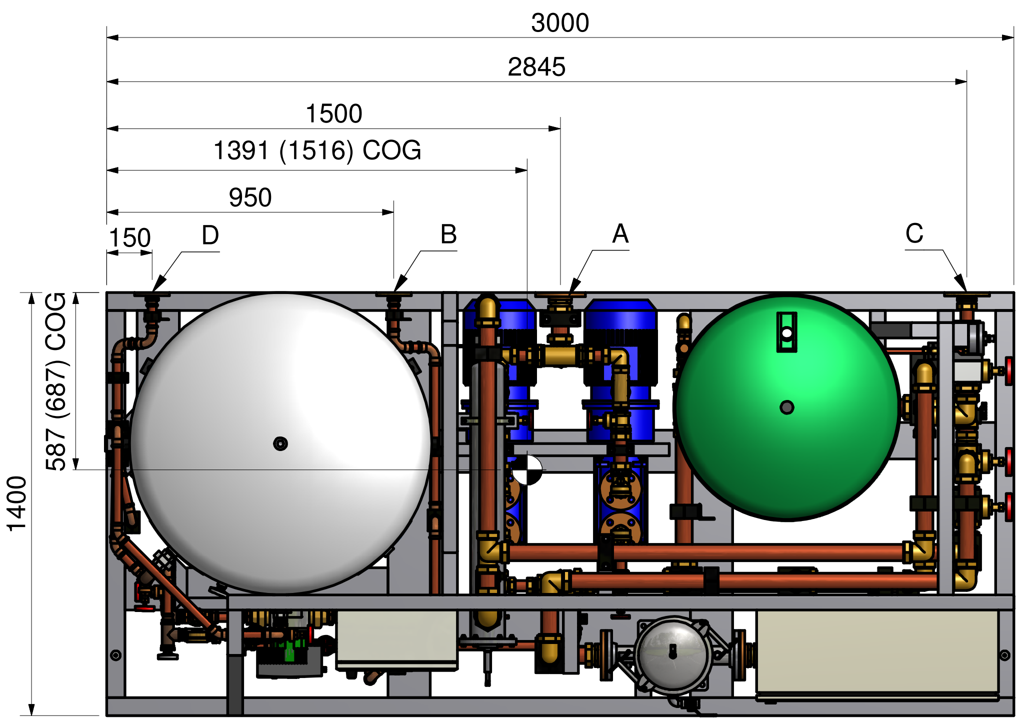
DRAWN_BY: A. Kruize
SCALE: N.A. (A3)
DATE: 26-04-13
FILENAME: F:\D\Damen shipyards\476032\P&ID.dwg
PROJECT: 476032
Sheet: 1 of 1
REV: 0

P&ID	P&ID2	Part	Brand	Type	Connect.	Max Pr.	Material	Power	kW	Remark	Part no.	No.
GV	0500-01a	Gate valve	Econ.	fig.290AA	1,5"		Brass				7220-M150A	1
GV	0500-01b	Gate valve	Econ.	fig.290AA	1,5"		Brass				7220-M150A	1
GV	0500-02a	Gate valve	Econ.	fig.290AA	1,25"		Brass				7220-M125A	1
GV	0500-02b	Gate valve	Econ.	fig.290AA	1,25"		Brass				7220-M125A	1
PI	0500-01a	Pressure gauge dia.63	ENFM	.-1/5bar gly	¼" onder		RVS/Ms				1902--10563OA	1
PI	0500-01b	Pressure gauge dia.63	ENFM	.-1/5bar gly	¼" onder		RVS/Ms				1902--10563OA	1
PI	0500-02a	Pressure gauge dia.63	ENFM	0-10bar-GLY	¼" onder		RVS/Ms				1902-010063OA	1
PI	0500-02b	Pressure gauge dia.63	ENFM	0-10bar- gly	¼" onder		RVS/Ms				1902-010063OA	1
		Gauge valve	Econ.		¼"	16bar	Brass				7206-050/342	4
ST	0500-01a	strainer			1,5"		Brass				7320-M150	1
ST	0500-01b	strainer			1,5"		Brass				7320-M150	1
CV	0500-01a	check valve			1,25"		Brass				7301-M125A/1210	1
CV	0500-01b	check valve			1,25"		Brass				7301-M125A/1210	1
PU	0500-01a	Pump IP55, isol.F	Speck	SK3203LA	DN32		Bronze	440V-60Hz	3,4		0425-SK3203LA	1
PU	0500-01b	Pump IP55, isol.F	Speck	SK3203LA	DN32		Bronze	440V-60Hz	3,4		0425-SK3203LA	1
HV	0500-01	hydrophore tank	Reflex	DT5 0400/10		10bar					0465-DT5400/10	1
PRV	0500-01a	Safety valve	Transmark	1215	1 "		Ms			setting 10bar	7310-B1001215	1
PI	0500-03	manometer dia.100	ENFM	0-10bar- gly			RVS/Ms				1902-010100OA	1
PS	0500-01	Pressure switch	Danfoss	CS2-6 IP55	½"bsp	10bar					1912-CS206IP5	1
PS	0500-02	Pressure switch	Danfoss	CS2-6 IP55	½"bsp	10bar					1912-CS206IP5	1
PT	0500-01	Pressure transmitter	Marktechn.	NAT 0-10.0A						0-10 bar	1923-NAT10A	1
BV	0500-01	Ball valve	Bosta	type 340	5/4"bsp		Brass				7202-M125340	1
BV	0500-02	Ball valve	Bosta	type 340	1"bsp		Brass				7202-M100340	1
BV	0500-03	Ball valve	Bosta	type 340	½"bsp		Brass				7202-M050340	1
BV	0500-04	3 way Ball valve	Econ.	Fig.1635T	½"bsp		Brass				6203-050316L/1635T	1
GV	0221-01	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
GV	0221-02	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
GV	0221-03	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
CF	0221-01	Filter house		HDCF 7-30	2" bspm		SS316			0235-OPTIEV+DP3-7	0235-HDCF0730	1
PI	0221-01	Pressure gauge dia.63	ENFM	0-10bar- gly	¼" onder		SS/Ms				1902-010063OA	1
		Gauge valve	Econ.		¼"	16bar	Brass				7206-050/342	1
GV	0430-01	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
GV	0430-02	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
GV	0430-03	Gate valve	Econ.	fig.290AA	2"bsp		Brass				7220-M200A	1
SV	0430-01	Solenoid valve	Inrada		1½"			230V-60Hz		option S	7255-M150220/40-60HZ	1
UV	0430-01	UV disinfection unit	Best UV	BM175/L2	DN40			230V-60Hz			1040-BM175/L2/1,5M/230/60/U/W	1
PI	0430-01	Pressure gauge dia.63	ENFM	0-10bar- gly	¼" onder		SS/Ms				1902-010063OA	1
		Gauge valve	Econ.		¼"	16bar	Brass				7206-050/342	1

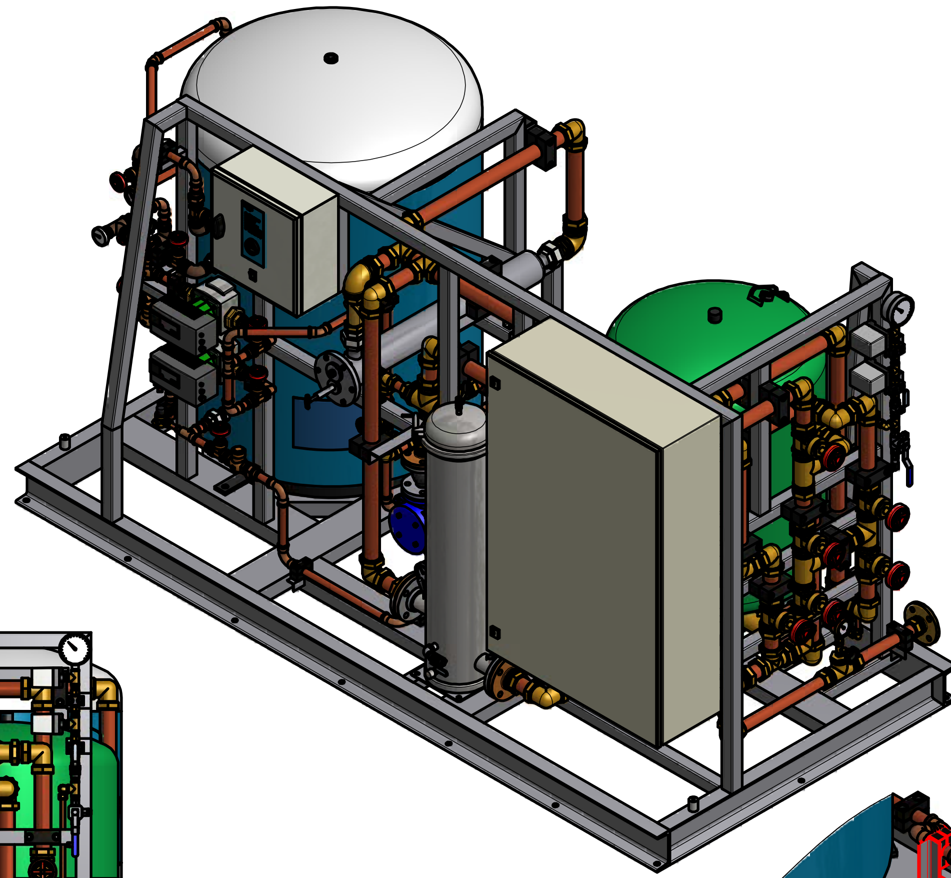
P&ID	P&ID2	Part	Brand	Type	Connect.	Max Pr.	Material	Power	kW	Remark	Part no.	No.
PU	0600-01a	Circilation Pump	WILO	Stratos Z 30/1-12				230V-60Hz	0,2		0450-000036	1
PU	0600-01b	Circilation Pump	WILO	Stratos Z 30/1-12				230V-60Hz	0,2		0450-000036	1
HWC	0600-01	Calorifier	Wesco	17RE1000 cut down	1"		SS	440V-60Hz	65kW		1800-17RE1000	1
PI	0600-01	Pressure indicator	ENFM	0 - 10 bar, ø63mm	¼"BSP		SS/Ms				1902-010063OA	1
TI	0600-01	Temp. indicator	Econosto	fig. 681, 0 - 120°C, ø63mm			SS				1930-0120A	1
		Zakbuis	Econosto	L=63mm	½"BSP		SS				1930-0120A/ZAKBUIS	1
BV		Manometerkraan	Econ.		¼"	16bar	Ms				7206-050/342	1
GV	0600-01a	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-02a	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-01b	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-02b	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-03	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-04	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-05	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
GV	0600-06	Gate valve	Econosto	Fig. 290	1"BSP		bronze				7220-B100A	1
CV	0600-01a	Check Valve	Econosto	fig.505TE	1"		bronze				7301-B100/S	1
CV	0600-01b	Check Valve	Econosto	fig.505TE	1"		bronze				7301-B100/S	1
CV	0600-03	Check Valve	Klinger	PN16	1"		Ms				7301-M100A/1210	1
		Filterelement		HAC24870							0210-HAC24870	21

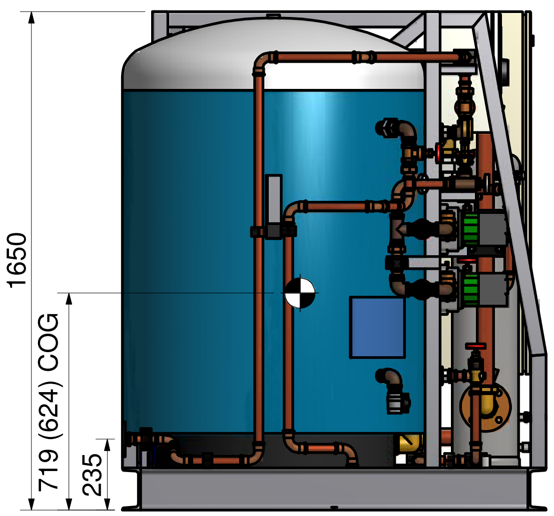
Weights:
Transport: approx. 1120 kg
Operational: approx. 2120 kg

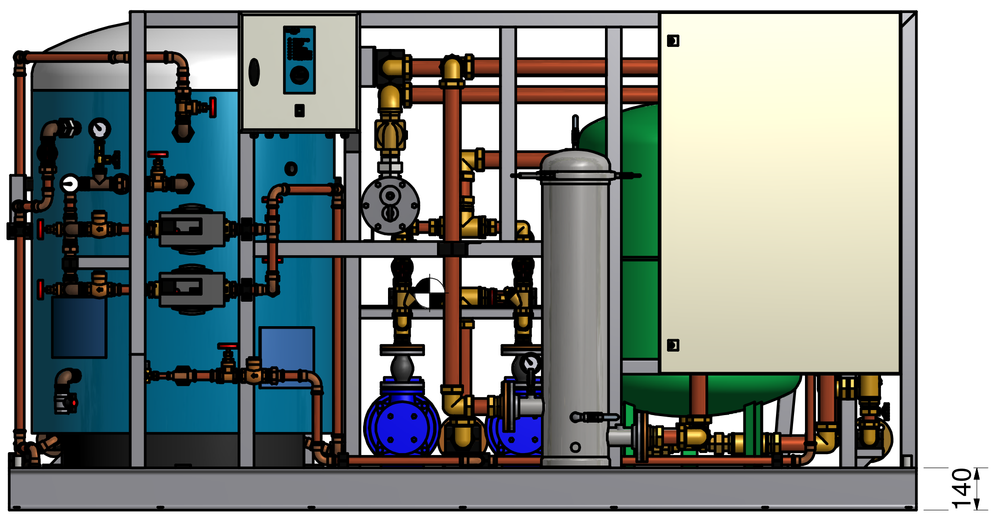
Center Of Gravity (COG)
operational (transport)

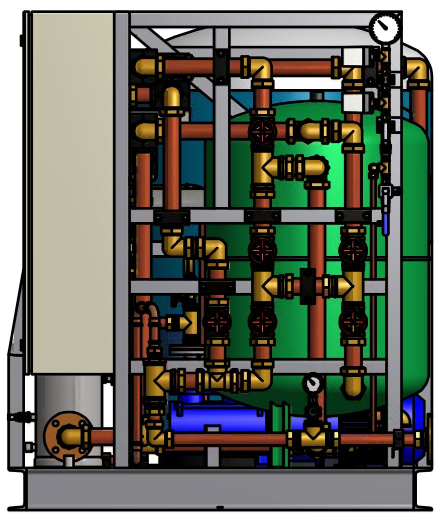


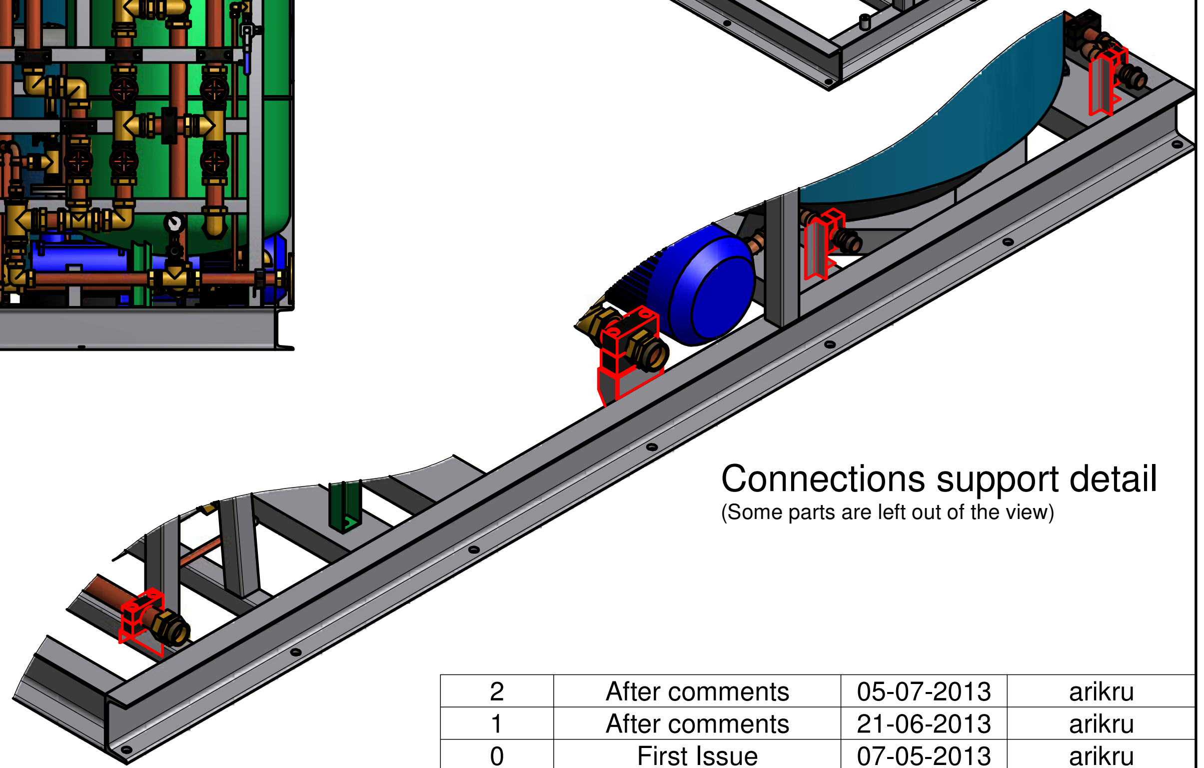
Connection Table		
Pos.	Description	Connection Type
A	Feed water in	Flange FF DN50 DIN PN16
B	Warm water circulation	Flange FF DN25 DIN PN16
C	Fresh water out	Flange FF DN40 DIN PN16
D	Warm water out	Flange FF DN25 DIN PN16



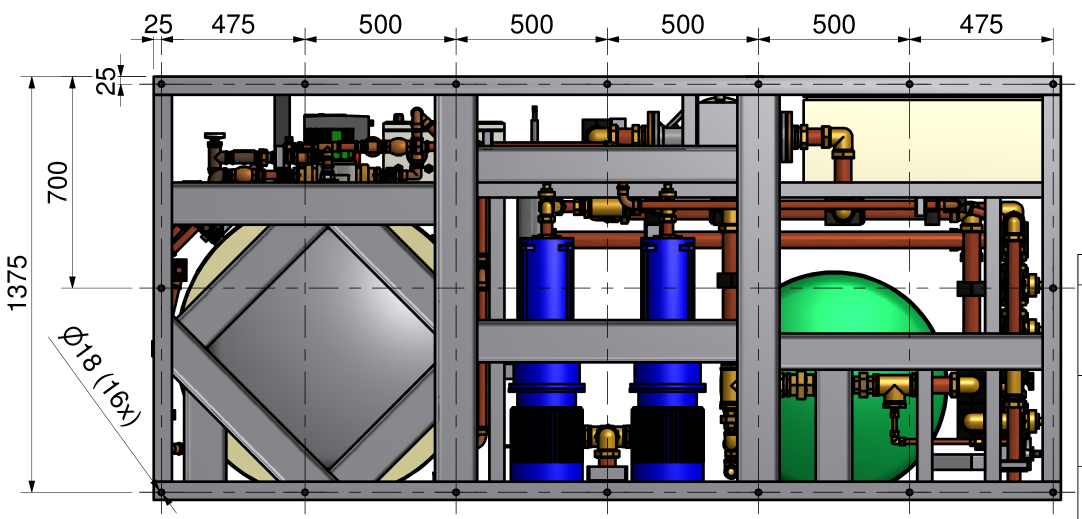








Connections support detail
(Some parts are left out of the view)



REV	DESCRIPTION	DATE	APP.
2	After comments	05-07-2013	arikru
1	After comments	21-06-2013	arikru
0	First Issue	07-05-2013	arikru

DIMENSIONS IN MM | SCALE: 1 : 25 | DRAWN: arikru | CLIENT: Damen Schelde Naval Shipbuilding

Layout

CLIENT REF: YN 414-PKR

General tolerance according to: NEN-ISO 2768-1

DESCRIPTION: Cold and Hot Water Unit 91-130 POB

HATENBOERWATER

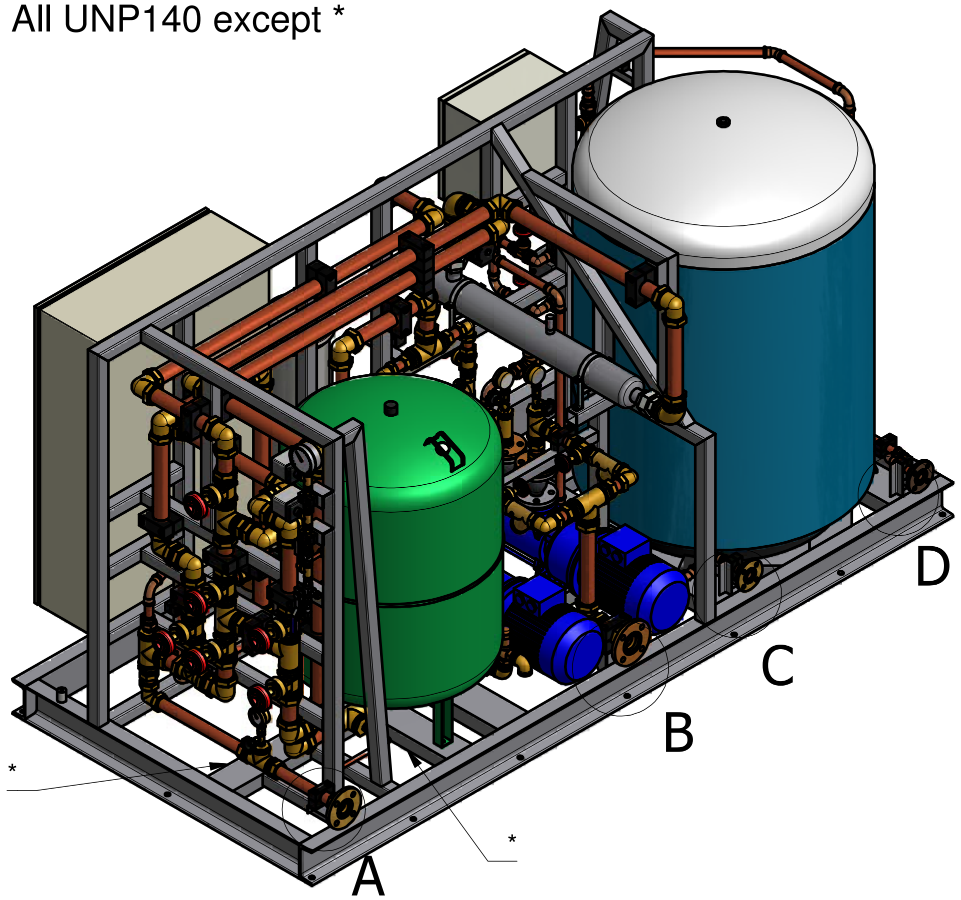
PROJECT No: 476032

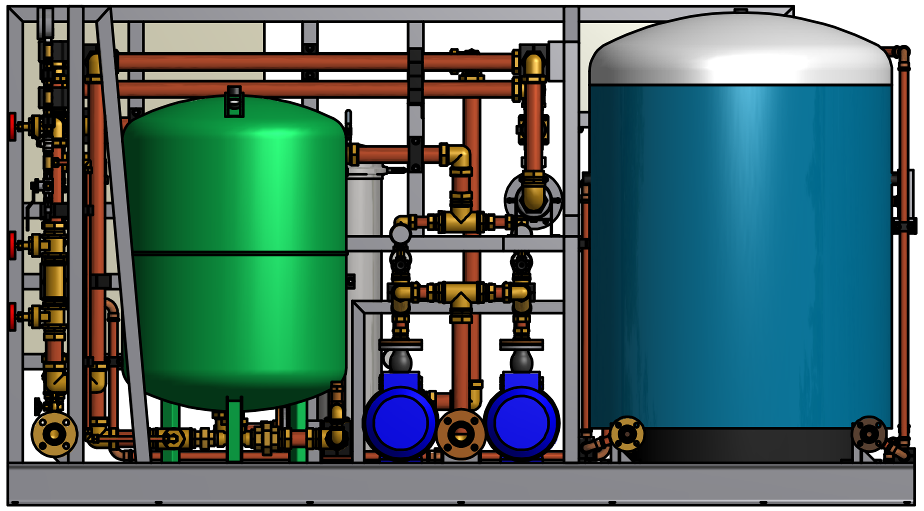
DRAWING No: 476032-101

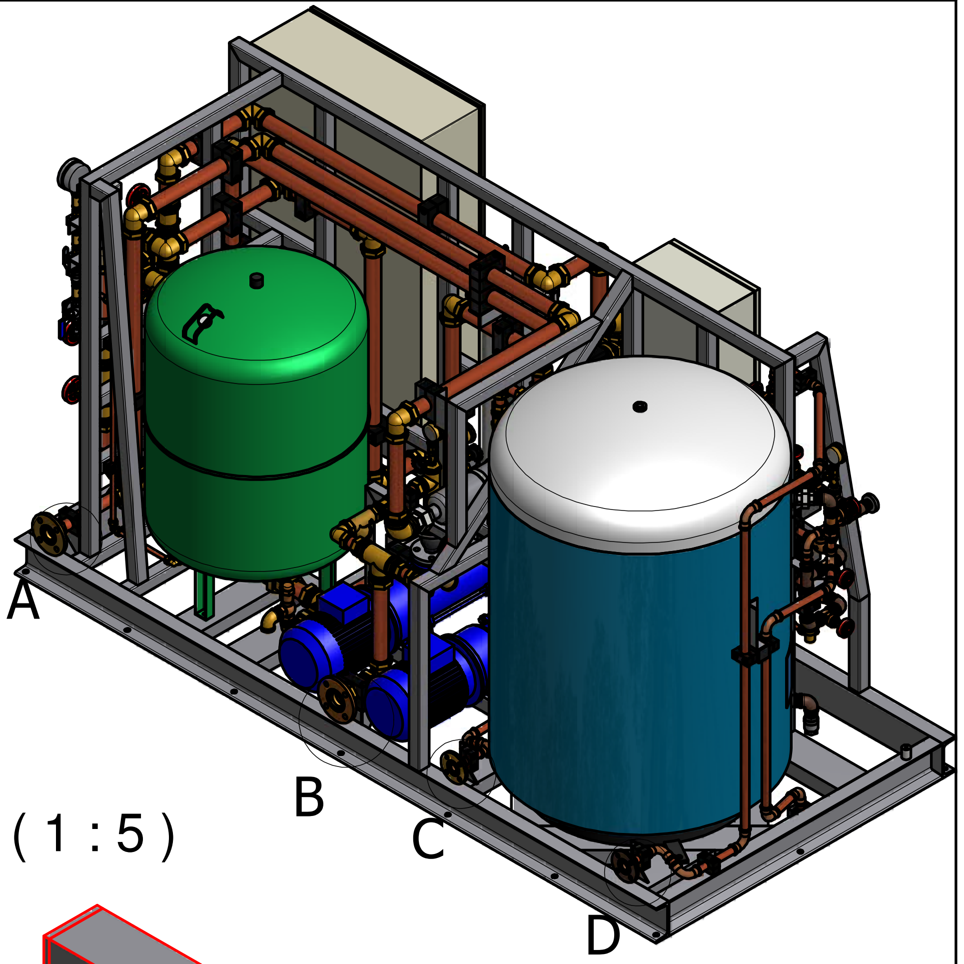
REV: 2

SIZE: A3

All UNP140 except *







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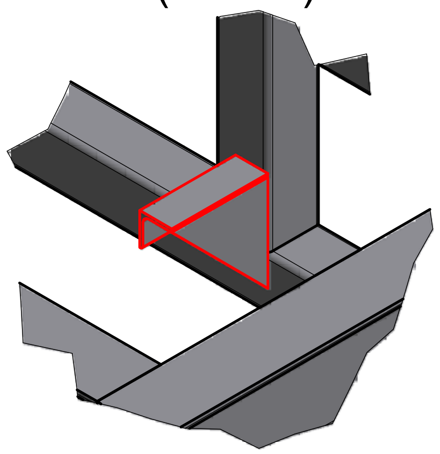

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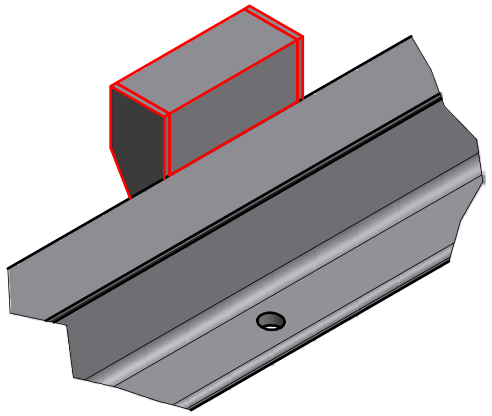

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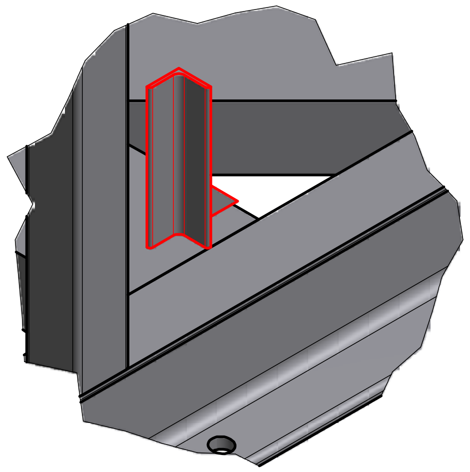

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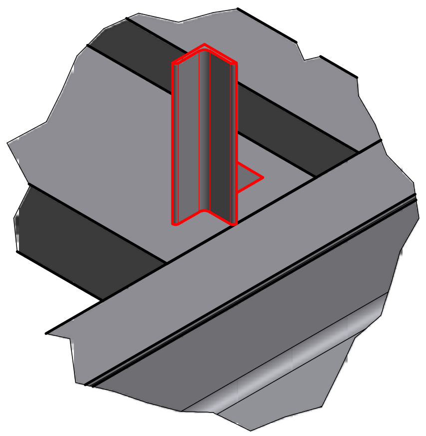

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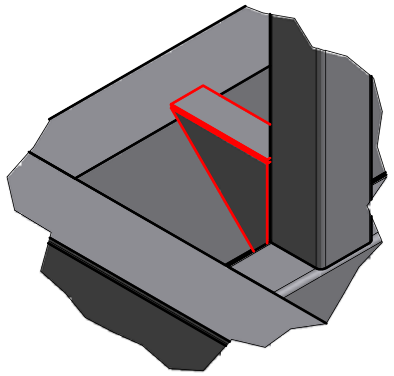

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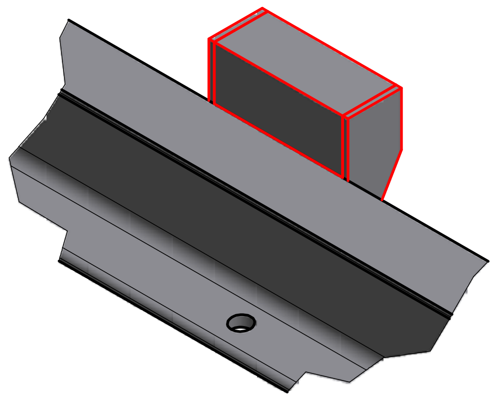

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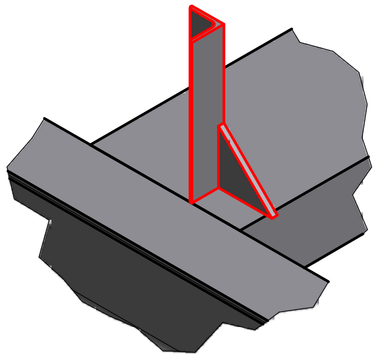
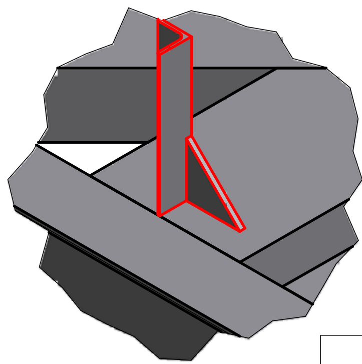


D (1 : 5)



REV	DESCRIPTION	DATE	APP.
0	For Information	05-07-2013	arikru

DIMENSIONS IN MM	SCALE: 1 : 25	DRAWN: arikru	CLIENT: Damen Schelde Naval Shipbuilding
	Layout Details		CLIENT REF: YN 414-PKR
General tolerance according to: NEN-ISO 2768-1	DESCRIPTION: Cold and Hot Water Unit 91-130 POB		
HATENBOERWATER	PROJECT No: 476032	DRAWING No: 476032-102	REV: 0 SIZE: A3

Hatenboer-Water BV

PORTABLE WATER SYSTEM
COLD & HOT WATER YNIT

CUSTOMER:

DAMEN SCHELDE NAVAL - SHIPBUILDING
YARD NR. 414 - PKR

PROJECT INFORMATION:

PROJECT ENGINEER:
PROJECT NUMBER : 476032-2
CABINET NUMBER : 13010358

CONCEPT 02-07-2013

Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	FRONT PAGE	Dwg.nr.: 13010358 Drawn : JPS Date : 02.05.2013 Rev. : JPS Date : 02.07.2013 Page: 1 of: 26

Pageno.	Designation	Additionals	Date	Engineer
1	FRONT PAGE		02.07.2013	JPS
2	INDEX		02.07.2013	JPS
3	GENERAL		02.07.2013	JPS
10	MAIN VOLTAGE		02.07.2013	JPS
11	MAIN VOLTAGE		02.07.2013	JPS
12	MAIN VOLTAGE		02.07.2013	JPS
13	CONTROL VOLTAGE		02.07.2013	JPS
14	CONTROL VOLTAGE		02.07.2013	JPS
15	CONTROL VOLTAGE HYDROPHORE PUMPS		02.07.2013	JPS
16	CONTROL VOLTAGE		02.07.2013	JPS
17	CONTROL VOLTAGE CENTRAL ALARM		02.07.2013	JPS
18	X1		02.07.2013	JPS
19	X3		02.07.2013	JPS
20	X4		02.07.2013	JPS
21	X6		02.07.2013	JPS
22	CABINET VIEW		02.07.2013	JPS
23	COMPONENT LIST		02.07.2013	JPS
24	COMPONENT LIST		02.07.2013	JPS
25	COMPONENT LIST		02.07.2013	JPS
26	COMPONENT LIST		02.07.2013	JPS

GENERAL

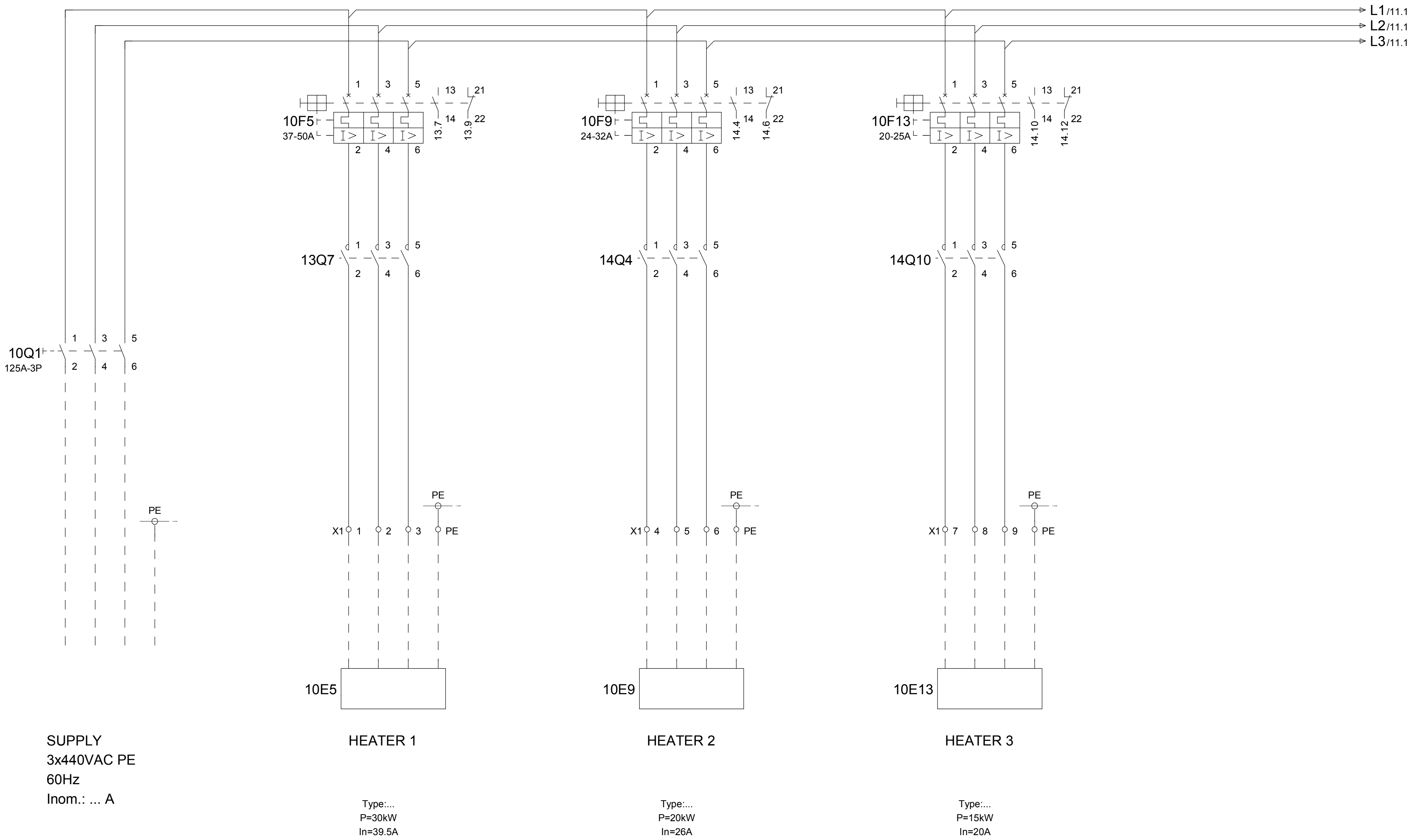
COLOR CODIFICATION WIRES		
MAIN CURRENT 3x440VAC	PHASE L1,L2,L3 EARTH	BLACK GREEN/YELLOW
CONTROL CURRENT 230VAC	PHASE - L1 SWITCHING WIRE NEUTRAL - L2 EARTH	BROWN BLACK BLUE GREEN/YELLOW
CONTROL CURRENT MAX.50VAC	PHASE SWITCHING WIRE NEUTRAL	ORANGE ORANGE WHITE
CONTROL CURRENT MAX.50VDC	PHASE SWITCHING WIRE NEUTRAL	RED RED WHITE
CONTROL EQUIPMENT	SURVEYORS / SENSORS ANALOG INPUT DIGITAL INPUT	GREY RED
CONTROL EQUIPMENT	CORRECTION EQUIPMENT ANALOG OUTPUT	PURPLE
EXTERNAL VOLTAGE	POT.FREE CONTACTS	TRANSPARENT

GENERAL:

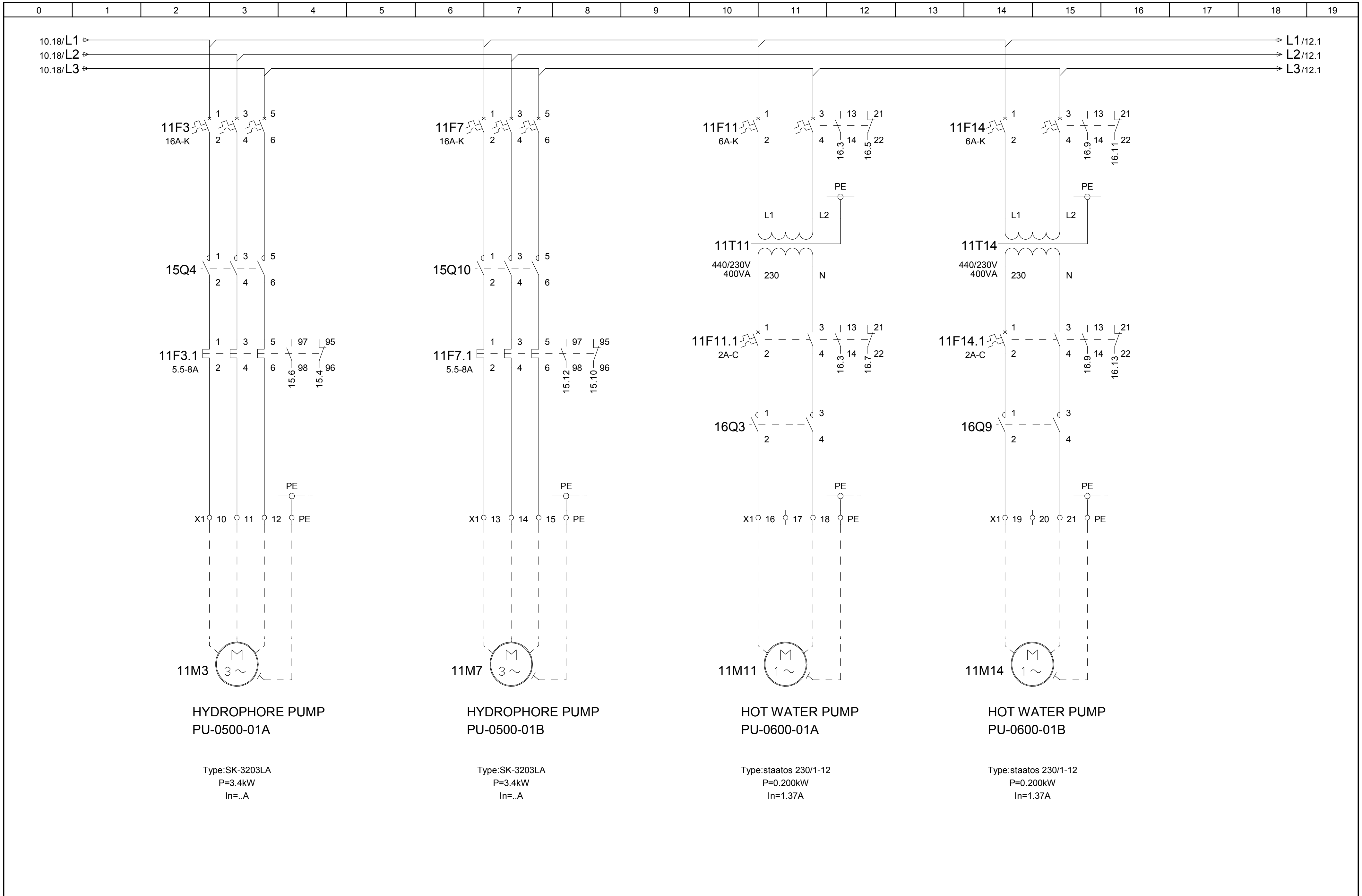
TERMINAL-CODING	
X0	SUPPLY 3x440VAC
X1	MAIN CURRENT 3x440VAC 230VAC
X2	CONTROL CURRENT 230VAC
X3 *	CONTROL CURRENT MAX. 50VAC / 50VDC
X4 *	SURVEYORS / SENSORS / ANALOG- AND DIGITAL INPUT
X6	EXTERNAL (STRANGE VOLTAGE) VOLTAGE

* WHEN YOU NEED A (SUPPLY) CURRENT ON ACTIVE SURVEYORS/SENSORS THE SURVEYOR/SENSOR DETERMINES TERMINAL-CODING (X4).

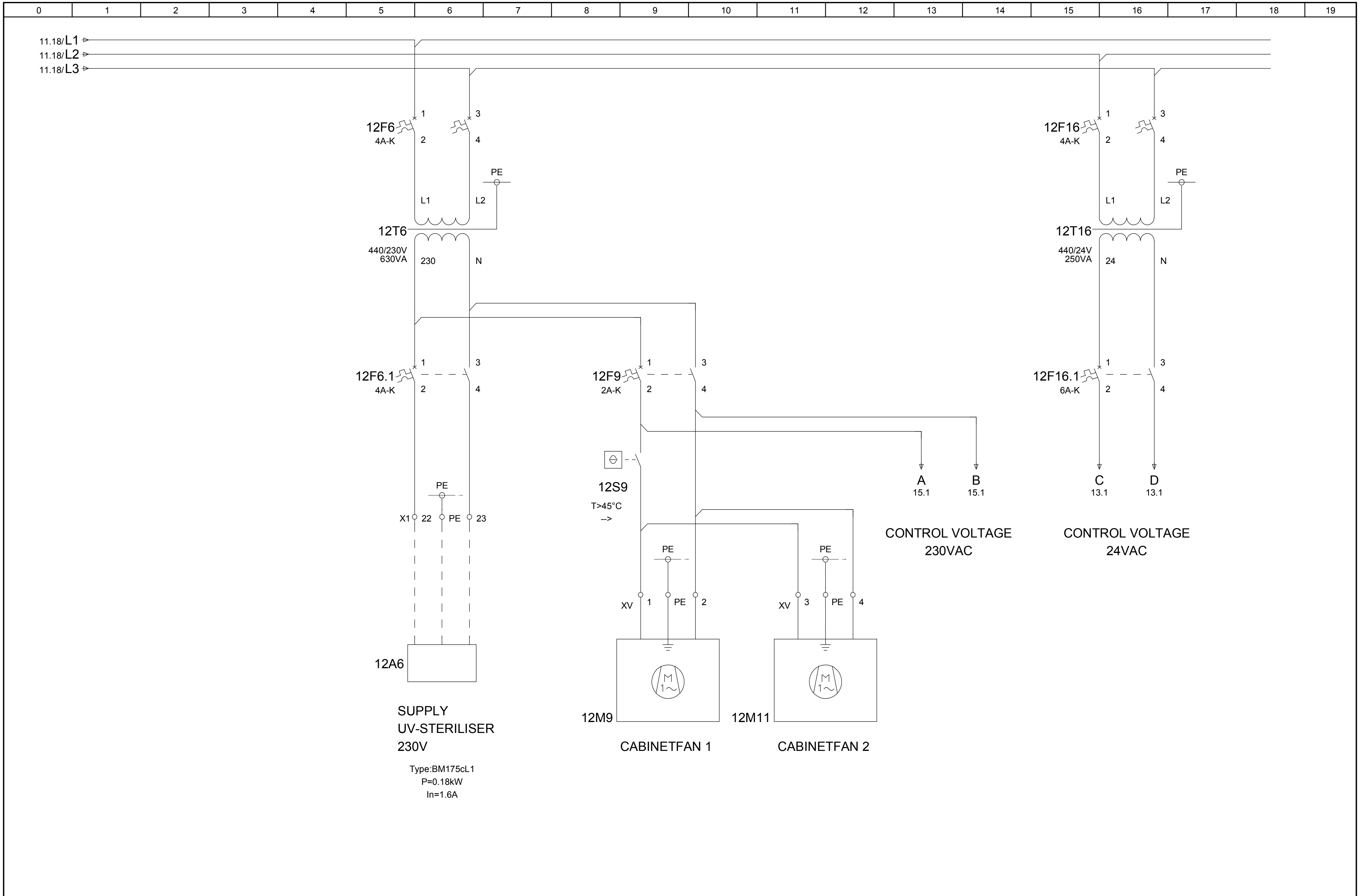
* WHEN YOU NEED A (SUPPLY) CURRENT ON CORECTION EQUIPMENT THE SUPPLY VOLTAGE DETERMINES TERMINAL-CODING (X4).



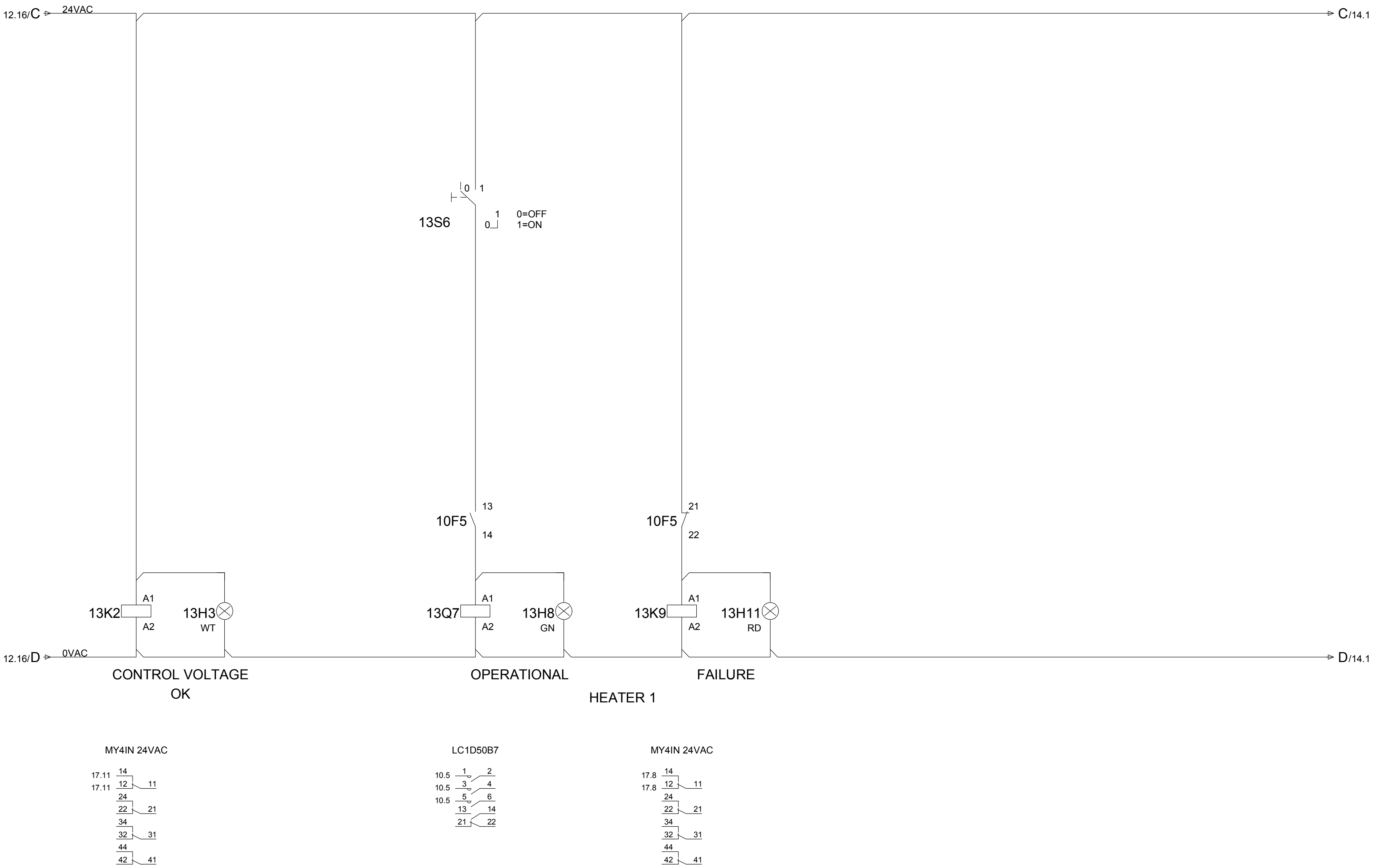
Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	MAIN VOLTAGE	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 10 of: 26



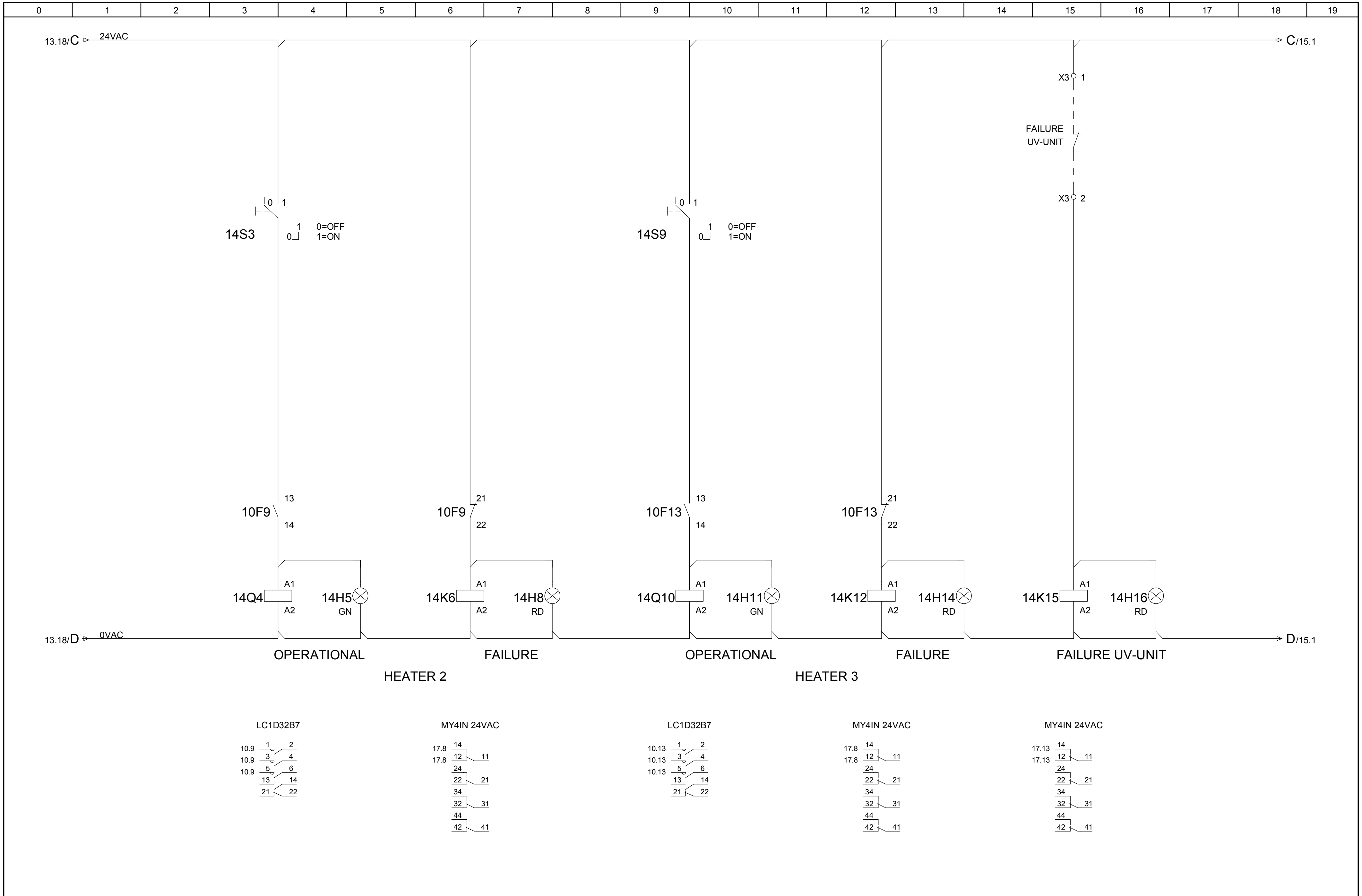
Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	MAIN VOLTAGE	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 11 of: 26



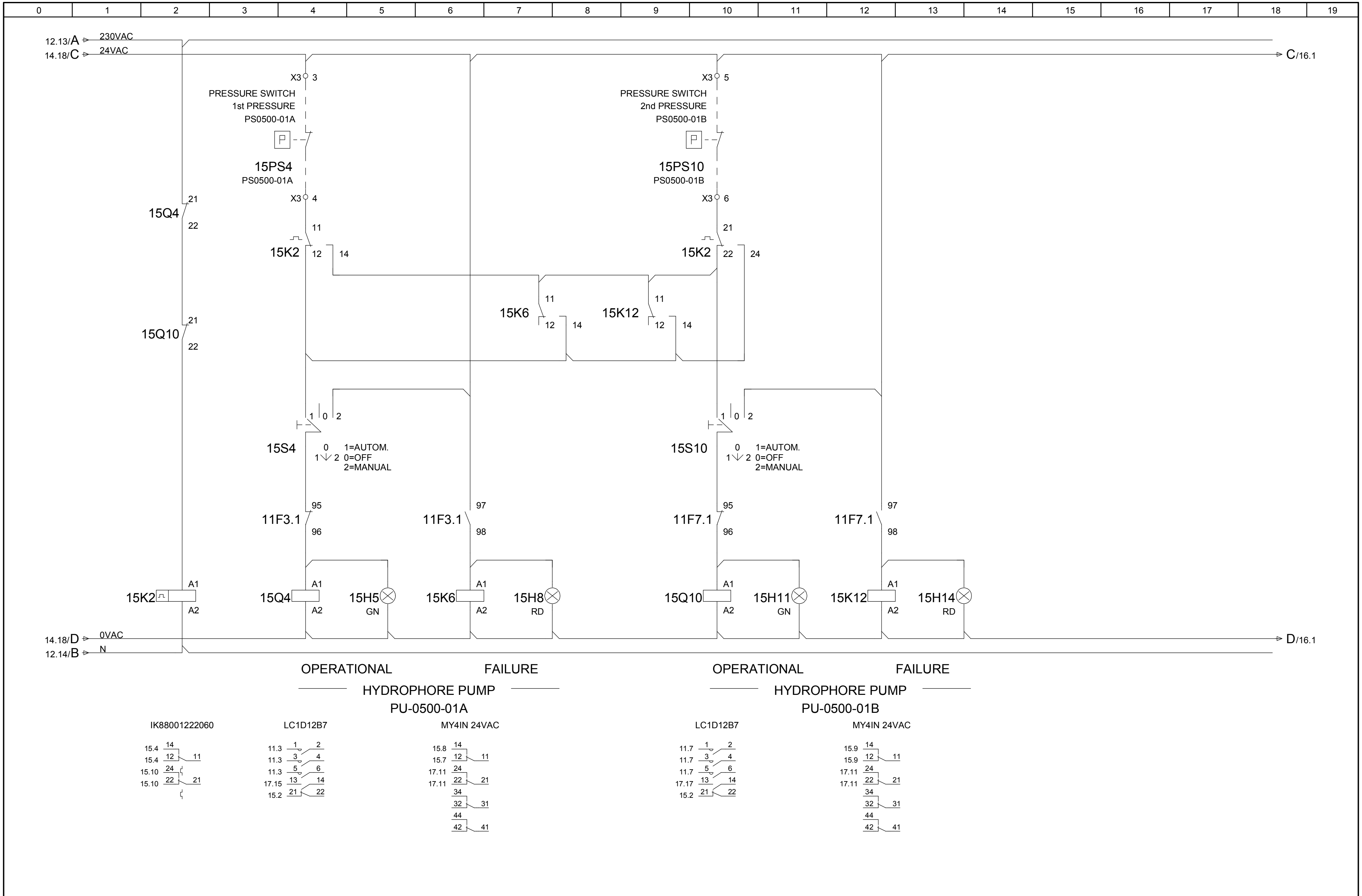
Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	MAIN VOLTAGE	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 12 of: 26



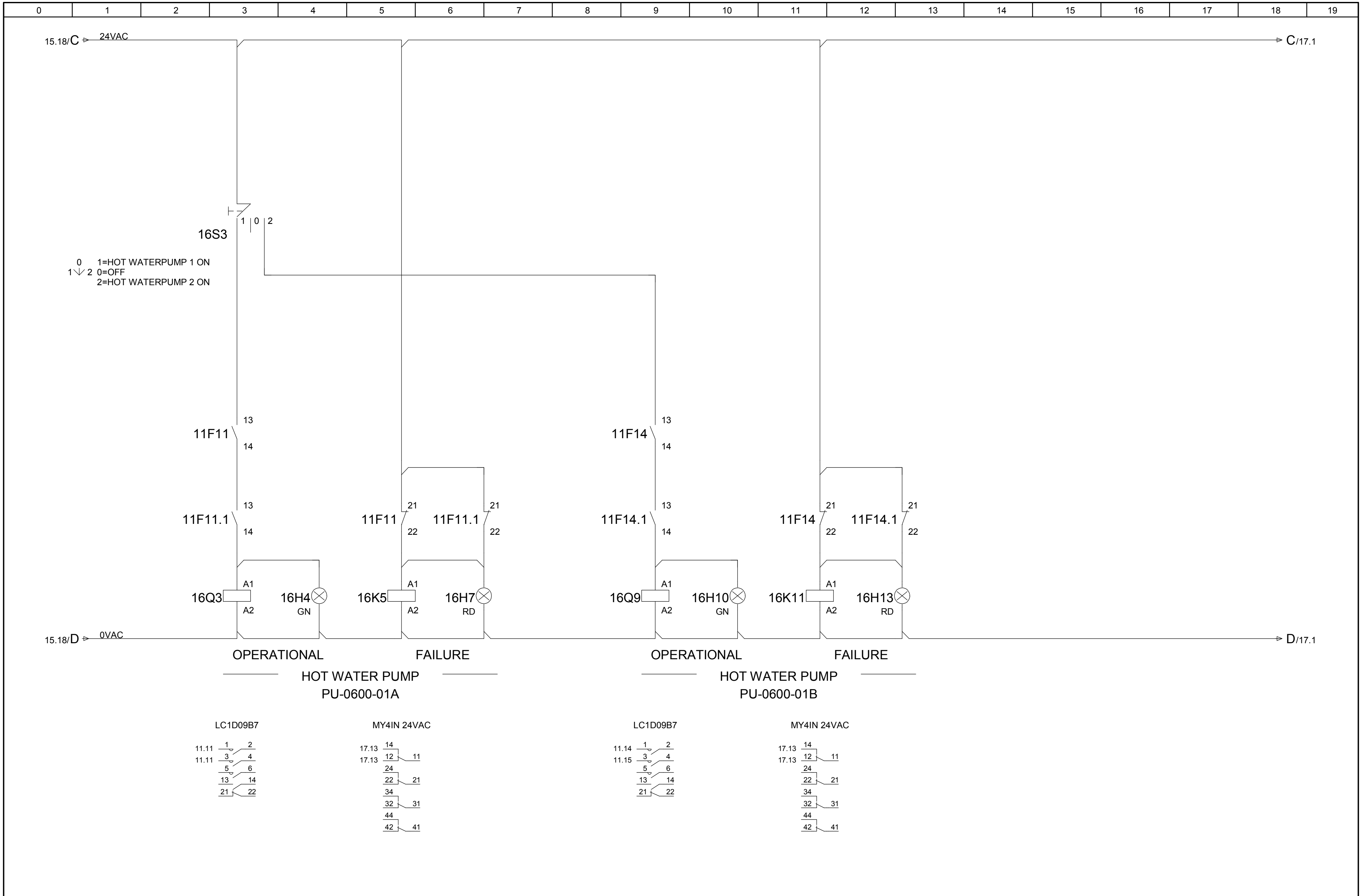
Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	CONTROL VOLTAGE	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 13 of: 26



Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	CONTROL VOLTAGE	Dwg.nr.: 13010358 Drawn: JPS Date: 02.05.2013 Rev.: JPS Date: 02.07.2013 Page: 14 of: 26



Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	CONTROL VOLTAGE HYDROPHORE PUMPS	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 15 of: 26

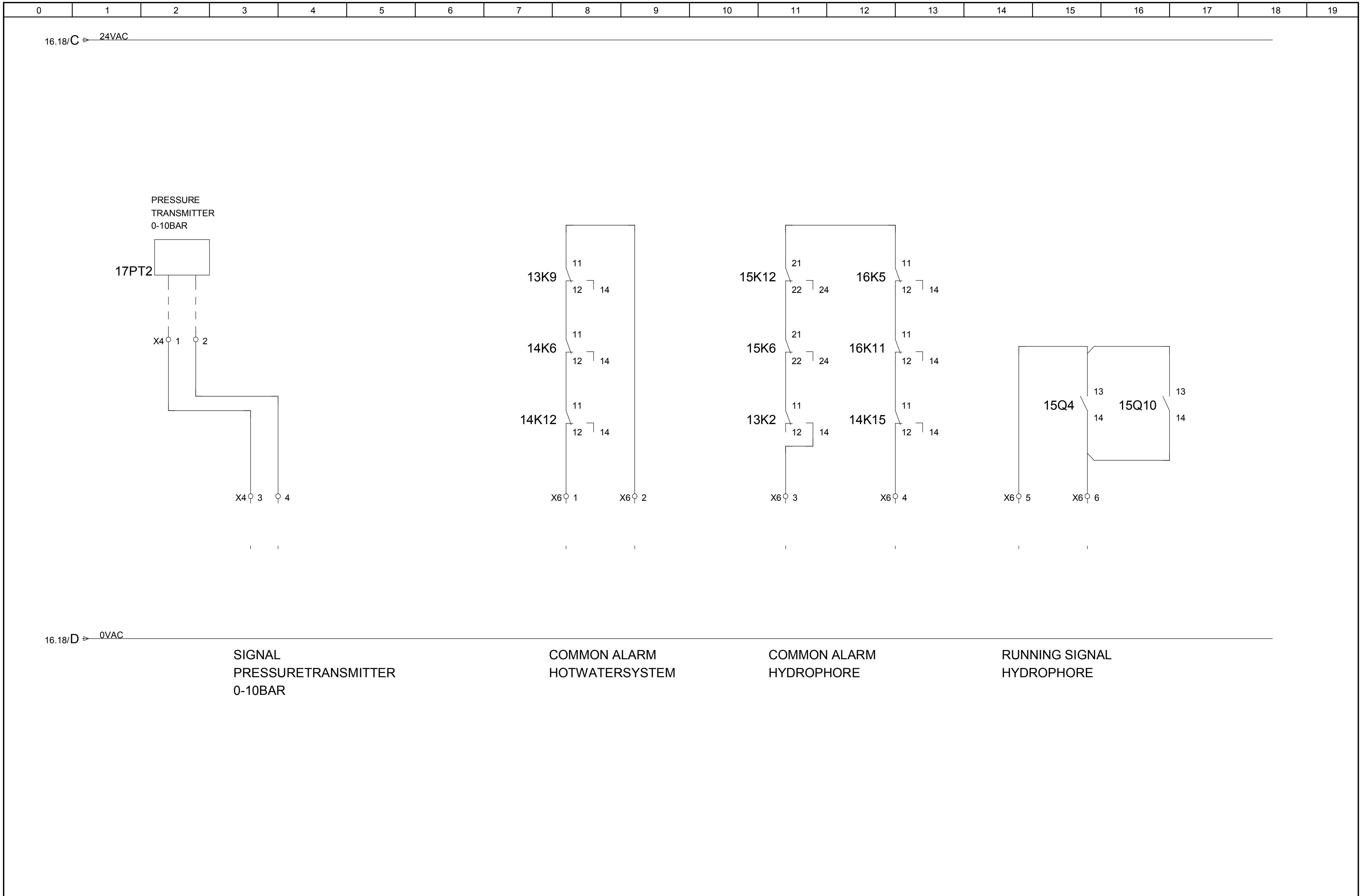


Hatenboer-Water BV
Postbus 6013
3002 AA Rotterdam

PORTABLE WATER SYSTEM
COLD & HOT WATER YNIT

CONTROL VOLTAGE

Dwg.nr.:	13010358		
Drawn :	JPS	Date:	02.05.2013
Rev. :	JPS	Date:	02.07.2013
Page:	16	of:	26



Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	CONTROL VOLTAGE CENTRAL ALARM	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 17 of: 26

cable	type of cable
W1-001	4x
W1-002	4x
W1-003	4x
W1-004	4x
W1-005	4x
W1-006	3x
W1-007	3x
W1-008	3x

X1

page/path	bridge connection	terminal	W1-001	W1-002	W1-003	W1-004	W1-005	W1-006	W1-007	W1-008	target	designation
10.5		1	1								10E5	SUPPLY 3x440VAC PE 60Hz Inom.: ... A
10.5		2	2								10E5	=
10.5		3	3								10E5	=
10.6		PE	PE								10E5	=
10.9		4		1							10E9	=
10.9		5		2							10E9	=
10.9		6		3							10E9	=
10.10		PE		PE							10E9	=
10.13		7			1						10E13	=
10.13		8			2						10E13	=
10.13		9			3						10E13	=
10.14		PE			PE						10E13	=
11.3		10				1					11M3	HYDROPHORE PUMP PU-0500-01A
11.3		11				2					11M3	=
11.3		12				3					11M3	=
11.4		PE				PE					11M3	=
11.7		13					1				11M7	HYDROPHORE PUMP PU-0500-01B
11.7		14					2				11M7	=
11.7		15					3				11M7	=
11.8		PE					PE				11M7	=
11.11		16						1			11M11	HOT WATER PUMP PU-0600-01A
11.11		17										=
11.11		18						2			11M11	=
11.12		PE						PE			11M11	=
11.14		19							1		11M14	HOT WATER PUMP PU-0600-01B
11.15		20										=
11.15		21							2		11M14	=
11.15		PE							PE		11M14	=
12.6		22								1	12A6	SUPPLY UV-STERILISER 230V
12.6		PE								PE	12A6	=
12.6		23								2	12A6	=

PE-TERMINAL = EARTHRAIL

page/path		15.4	15.4	15.10	15.10
	bridge connection				
X3	terminal	1	2	3	4
cable	type of cable				
W3-001	2x	1	2		
W3-002	2x			1	2
		15PS4	15PS4	15PS10	15PS10
	designation	PRESSURE SWITCH 1st PRESSURE PS0500-01A	"	PRESSURE SWITCH 2nd PRESSURE PS0500-01B	"

PE-TERMINAL = EARTHRAIL

Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	X3	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 19 of: 26

	page/path	17.2	17.2	17.3	17.4
	bridge connection				
X4	terminal	1	2	3	4
cable	type of cable				
W4-001	2x	1	2		
W4-002	2x			1	2
		17PT2	17PT2	PT	PT
	designation	PRESSURE TRANSMITTER 0-10BAR	=	SIGNAL PRESSURETRANSMITTER 0-10BAR	=

PE-TERMINAL = EARTHRAIL

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

	page/path	17.8	17.9	17.11	17.13	17.14	17.15
	bridge connection						
X6	terminal	1	2	3	4	5	6
cable	type of cable						
W6-001	2x	1	2				
W6-002	2x			1	2		
W6-003	2x					1	2
		CHW	CHW	CHF	CHF	CHW	CHW
	designation	COMMON ALARM HOTWATERSYSTEM	=	COMMON ALARM HYDROPHORE	=	RUNNING SIGNAL HYDROPHORE	=

PE-TERMINAL = EARTHRAIL

Hatenboer-Water BV
Postbus 6013
3002 AA Rotterdam

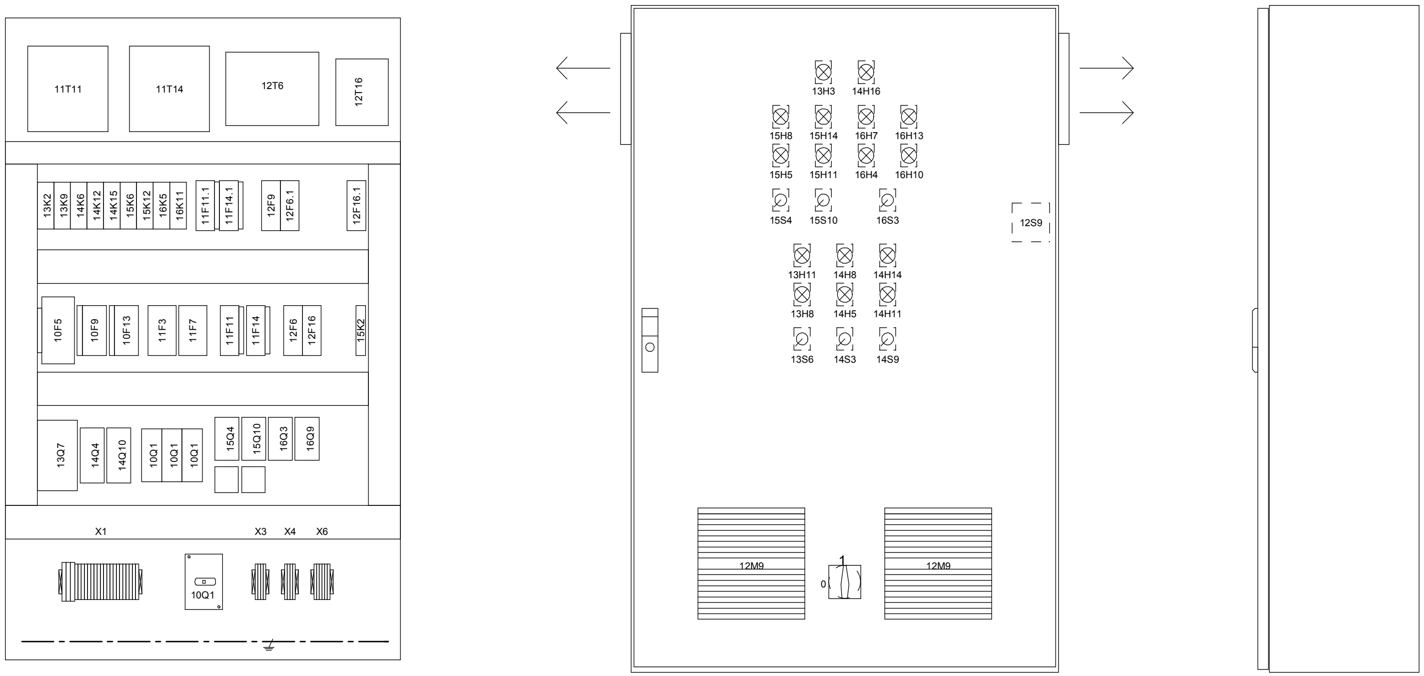
PORTABLE WATER SYSTEM
COLD & HOT WATER YNIT

X6

Dwg.nr.: 13010358
Drawn : JPS Date: 02.05.2013
Rev. : JPS Date: 02.07.2013

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

MOUNTING PLATE FRONT VIEW SIDE VIEW



CABINET :
RITTAL AE1280.500
1200x800x300 (HxWxD)

Hatenboer-Water BV Postbus 6013 3002 AA Rotterdam	PORTABLE WATER SYSTEM COLD & HOT WATER YNIT	CABINET VIEW	Dwg.nr.: 13010358 Drawn : JPS Date: 02.05.2013 Rev. : JPS Date: 02.07.2013 Page: 22 of: 26

PARTNO.	AMOUNT	ARTICLE NUMBER	SUPPLIER	DESIGNATION
	1	AE1280.500	RITTAL	CABINET 1200 X 800 X 300 RAL7035
	4	SZ2508.010	RITTAL	WALLMOUNTING BRACKET 10MM AE CABINET
	1	0.88.200.0	NDU	DRAWING HOLDER GREY A4
X1	3	WDU6	WEIDMÜLLER	TERMINAL 6MM²
X1	20	WDU4	WEIDMÜLLER	TERMINAL 4MM²
X3	6	WDU2.5	WEIDMÜLLER	TERMINAL 2.5MM²
X4	4	WDU2.5	WEIDMÜLLER	TERMINAL 2.5MM²
X6	6	WDU2.5	WEIDMÜLLER	TERMINAL 2.5MM²
10F5	1	GV3P50	SCHNEIDER	MOTORBEVEILIGINGSSCHAKELAAR 37-50A
10F5	1	GV3A01	TELEMECANIQUE	AUXILIARY CONTACTBLOK 1NO1NC
10F9	1	GV2ME32	TELEMECANIQUE	MOTOR-PROTECTIVE CIRCUIT-BREAKER 24-32A
10F9	1	GVAN11	TELEMECANIQUE	LATERAL AUXILIARY CONTACT 1NO 1NC
10F13	1	GV2ME22	TELEMECANIQUE	MOTOR-PROTECTIVE CIRCUIT-BREAKER 20-25A
10F13	1	GVAN11	TELEMECANIQUE	LATERAL AUXILIARY CONTACT 1NO 1NC
10Q1	1	OT125F3	ABB	SWITCH-DISCONNECTOR 125A 3P DINRAIL
10Q1	1	OXP 6X360	ABB	SHAFT 6X6X330MM
10Q1	1	OHY 45J6	ABB	PISTOOLGREEP, ROOD/GEEL DIAMETER 6 MM, VERGRE
10Q1	3	04031	MERLIN GERIN	POLYBLOC 70MM² => 6X16MM²
11F3	1	S203K16	ABB	6KA CIRCUITBREAKER 3P K 16A
11F3.1	1	LRD12	TELEMECANIQUE	OVERLOAD RELAY 5.5-8A
11F7	1	S203K16	ABB	6KA CIRCUITBREAKER 3P K 16A
11F7.1	1	LRD12	TELEMECANIQUE	OVERLOAD RELAY 5.5-8A
11F11	1	S202K6	ABB	6KA CIRCUITBREAKER 2P K 6A
11F11	1	S2C-H11L	ABB	HULPCONTACT 1M1V LATERAAL S/F/DS200
11F11.1	1	S201C2NA	ABB	6KA CIRCUITBREAKER 1P+N C 2A
11F11.1	1	S2C-H11L	ABB	HULPCONTACT 1M1V LATERAAL S/F/DS200
11F14	1	S202K6	ABB	6KA CIRCUITBREAKER 2P K 6A
11F14	1	S2C-H11L	ABB	HULPCONTACT 1M1V LATERAAL S/F/DS200
11F14.1	1	S201C2NA	ABB	6KA CIRCUITBREAKER 1P+N C 2A
11F14.1	1	S2C-H11L	ABB	HULPCONTACT 1M1V LATERAAL S/F/DS200
11T11	1	CT156NN	ETI	TRANSFORMER 360-460V/230V 400VA
11T14	1	CT156NN	ETI	TRANSFORMER 360-460V/230V 400VA
12F6	1	S202K4	ABB	6KA CIRCUITBREAKER 2P K 4A
12F6.1	1	S201K4NA	ABB	6KA CIRCUITBREAKER 1P+N K 4A
12F9	1	S201K2NA	ABB	6KA CIRCUITBREAKER 1P+N K 2A
12F16	1	S202K4	ABB	6KA CIRCUITBREAKER 2P K 4A
12F16.1	1	S201K6NA	ABB	CIRCUIT BREAKER 6KA 1P+N K 6A
12M9	1	LV-335/230VAC	RUBSAMEN	FILTERFAN 204X204MM 90M3/H RAL7035
12M9	1	GV-300/7035	RUBSAMEN	EXHAUST FILTER 204X204MM RAL7035
12M9	2	WDU2.5	WEIDMÜLLER	TERMINAL 2.5MM²

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

PARTNO.	AMOUNT	ARTICLE NUMBER	SUPPLIER	DESIGNATION
12M9	1	WPE 2.5	WEIDMÜLLER	EARTH TERMINAL 2.5MM²
12M11	1	LV-335/230VAC	RUBSAMEN	FILTERFAN 204X204MM 90M3/H RAL7035
12M11	1	GV-300/7035	RUBSAMEN	EXHAUST FILTER 204X204MM RAL7035
12M11	2	WDU2.5	WEIDMÜLLER	TERMINAL 2.5MM²
12M11	1	WPE 2.5	WEIDMÜLLER	EARTH TERMINAL 2.5MM²
12S9	1	SK3110000		
12T6	1	CT159NN	ETI	TRANSFORMER 360-520/230V 630VA
12T16	1	CT145NN24	ETI	TRANSFORMER 360-520/24V 250VA
13H3	1	M22-L-W	MOELLER	LENS FLAT IP67 WHITE
13H3	1	M22-A	MOELLER	FIXING ADAPTER
13H3	1	M22-CLED-W	MOELLER	LED FRONTM. 18-30V WHITE CAGE
13H8	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
13H8	1	M22-A	MOELLER	FIXING ADAPTER
13H8	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
13H11	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
13H11	1	M22-A	MOELLER	FIXING ADAPTER
13H11	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
13K2	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
13K2	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
13K9	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
13K9	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
13Q7	1	LC1D50B7	TELEMECANIQUE	CONTACTOR 24V~ 22KW 3P1NO1NC
13S6	1	M22-WRK	MOELLER	SELECTOR SWITCH ACTUATOR 60° 0-1 0
13S6	1	M22-A	MOELLER	FIXING ADAPTER
13S6	1	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE
14H5	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
14H5	1	M22-A	MOELLER	FIXING ADAPTER
14H5	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
14H8	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
14H8	1	M22-A	MOELLER	FIXING ADAPTER
14H8	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
14H11	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
14H11	1	M22-A	MOELLER	FIXING ADAPTER
14H11	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
14H14	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
14H14	1	M22-A	MOELLER	FIXING ADAPTER
14H14	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
14H16	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
14H16	1	M22-A	MOELLER	FIXING ADAPTER
14H16	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

PARTNO.	AMOUNT	ARTICLE NUMBER	SUPPLIER	DESIGNATION
14K6	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
14K6	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
14K12	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
14K12	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
14K15	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
14K15	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
14Q4	1	LC1D32B7	TELEMECANIQUE	CONTACTOR 24V~ 15KW 3P1NO1NC
14Q10	1	LC1D32B7	TELEMECANIQUE	CONTACTOR 24V~ 15KW 3P1NO1NC
14S3	1	M22-WRK	MOELLER	SELECTOR SWITCH ACTUATOR 60° 0-1 0
14S3	1	M22-A	MOELLER	FIXING ADAPTER
14S3	1	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE
14S9	1	M22-WRK	MOELLER	SELECTOR SWITCH ACTUATOR 60° 0-1 0
14S9	1	M22-A	MOELLER	FIXING ADAPTER
14S9	1	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE
15H5	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
15H5	1	M22-A	MOELLER	FIXING ADAPTER
15H5	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
15H8	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
15H8	1	M22-A	MOELLER	FIXING ADAPTER
15H8	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
15H11	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
15H11	1	M22-A	MOELLER	FIXING ADAPTER
15H11	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
15H14	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
15H14	1	M22-A	MOELLER	FIXING ADAPTER
15H14	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
15K2	1	IK88001222060	DOLD	STAPPENRELAIS 2M2V 220V 60HZ
15K6	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
15K6	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
15K12	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
15K12	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
15Q4	1	LC1D12B7	TELEMECANIQUE	CONTACTOR 24V~ 5.5KW 3P1NO1NC
15Q10	1	LC1D12B7	TELEMECANIQUE	CONTACTOR 24V~ 5.5KW 3P1NO1NC
15S4	1	M22-WRK3	MOELLER	SELECTOR SWITCH ACTUATOR 60° 1-0-2
15S4	1	M22-A	MOELLER	FIXING ADAPTER
15S4	2	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE
15S10	1	M22-WRK3	MOELLER	SELECTOR SWITCH ACTUATOR 60° 1-0-2
15S10	1	M22-A	MOELLER	FIXING ADAPTER
15S10	2	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE
16H4	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

PARTNO.	AMOUNT	ARTICLE NUMBER	SUPPLIER	DESIGNATION
16H4	1	M22-A	MOELLER	FIXING ADAPTER
16H4	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
16H7	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
16H7	1	M22-A	MOELLER	FIXING ADAPTER
16H7	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
16H10	1	M22-L-G	MOELLER	LENS FLAT IP67 GREEN
16H10	1	M22-A	MOELLER	FIXING ADAPTER
16H10	1	M22-CLED-G	MOELLER	LED FRONTM. 18-30V GREEN CAGE
16H13	1	M22-L-R	MOELLER	LENS FLAT IP67 RED
16H13	1	M22-A	MOELLER	FIXING ADAPTER
16H13	1	M22-CLED-R	MOELLER	LED FRONTM. 18-30V RED CAGE
16K5	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
16K5	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
16K11	1	MY4IN 24VAC	OMRON	AUXILIARY RELAY 24VAC 4CH LED+TEST
16K11	1	PYF14S	OMRON	SOCKET FOR MY4 RELAY (CAGE)
16Q3	1	LC1D09B7	TELEMECANIQUE	CONTACTOR 24V~ 4KW 3P1NO1NC
16Q9	1	LC1D09B7	TELEMECANIQUE	CONTACTOR 24V~ 4KW 3P1NO1NC
16S3	1	M22-WRK3	MOELLER	SELECTOR SWITCH ACTUATOR 60° 1-0-2
16S3	1	M22-A	MOELLER	FIXING ADAPTER
16S3	2	M22-CK10	MOELLER	CONTACT ELEMENT 1NO CAGE

SPECK PUMPEN
WALTER SPECK KG
D-91142 ROTH

Kennlinienblatt/Curve of performance characteristics Type SK 32	Kennl.-Bl. Nr. / Curve No. KL 14.32.007
Kunde / Customer	Gez. : Wolf Datum : 19.01.1998

Saugstutzen/Suction branch DN 32	Druckstutzen/Delivery branch DN 32	
Laufrad/Impeller Gehäuse/Casing	Drehzahl / Speed 1750 1/min	Meßspiel nach DIN 1944/III Bauspiel : Q,H ±5% P +10%